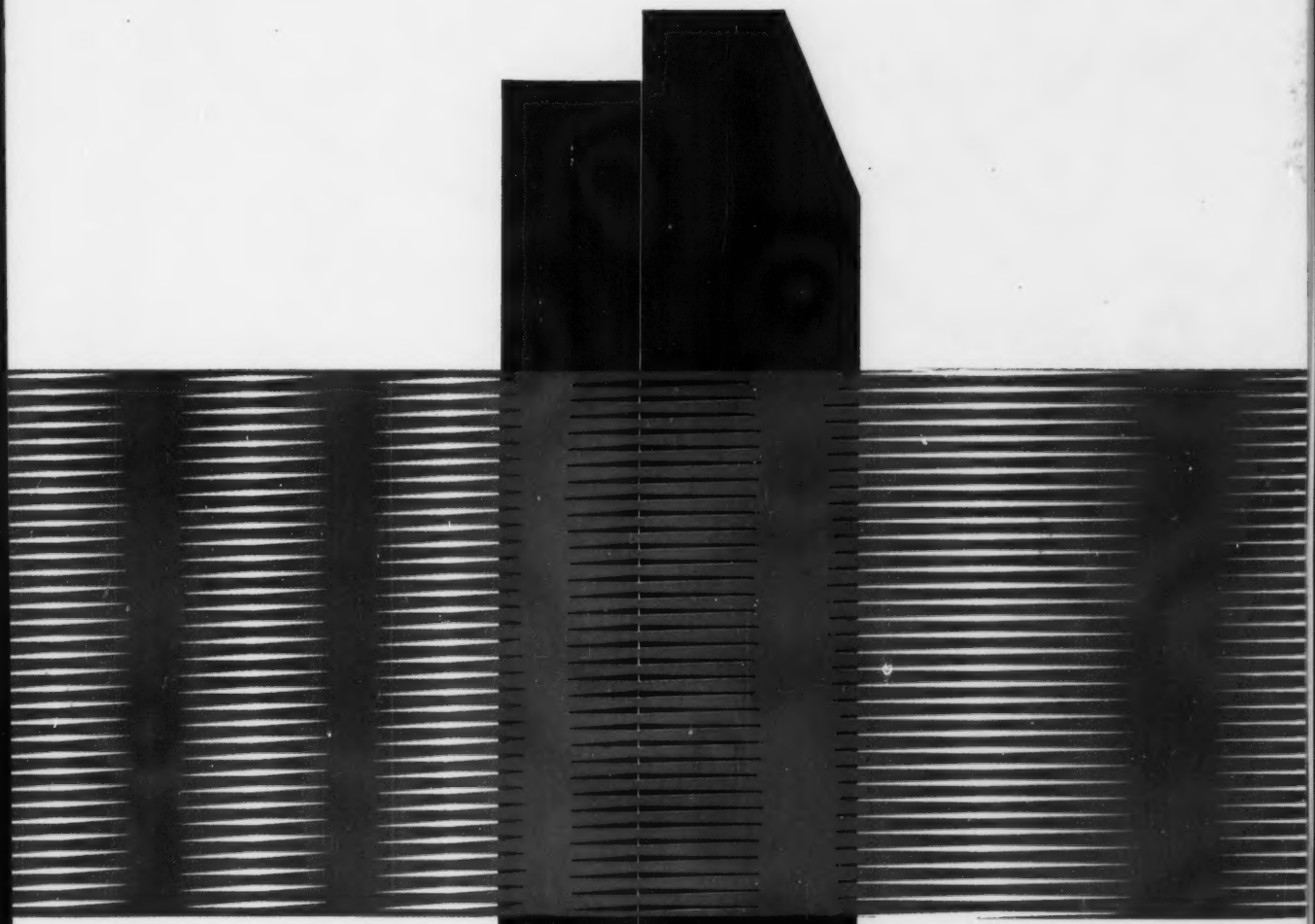
SEPTEMBER 15, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

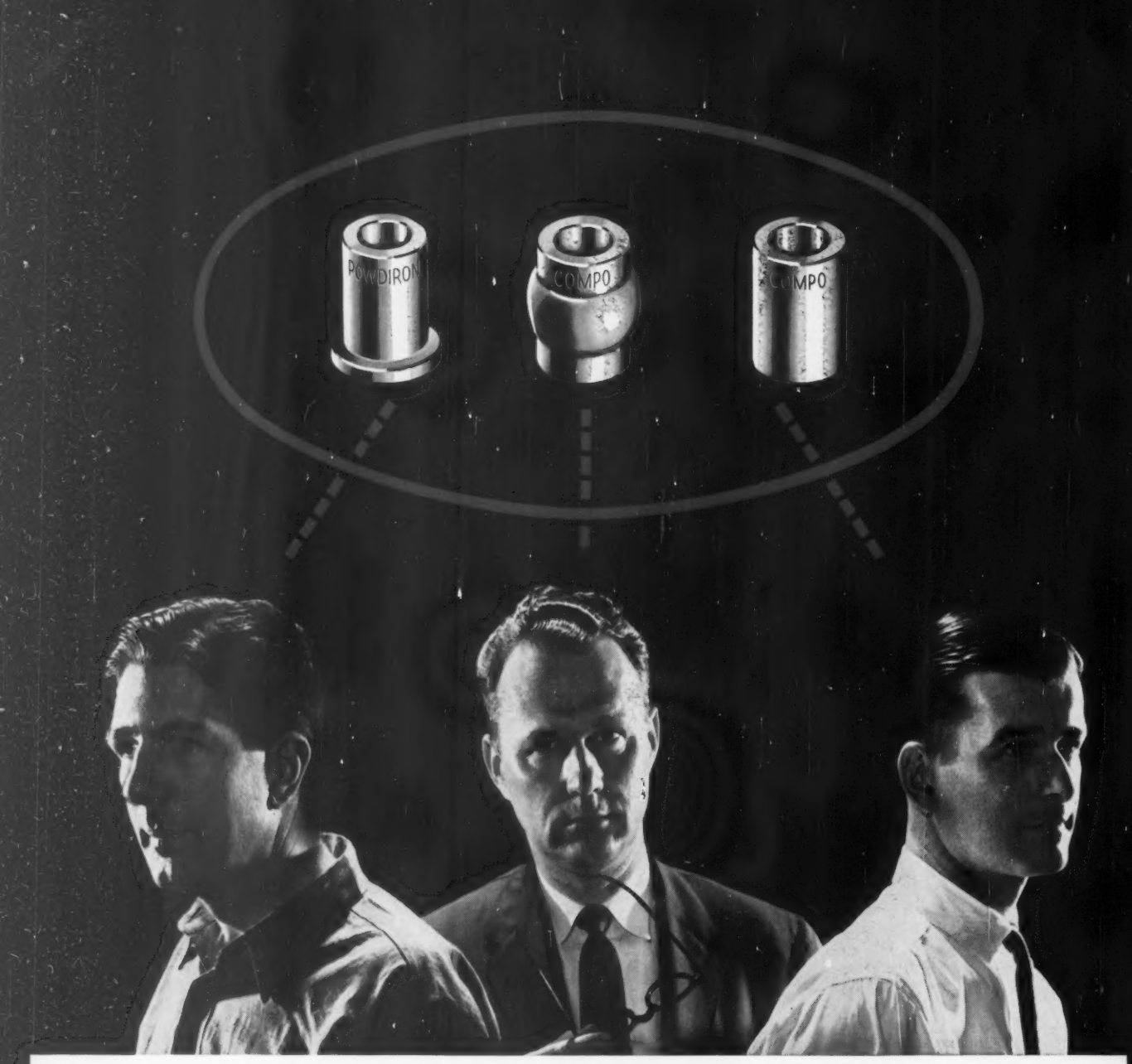


# Thermal Conductance Across Metal Joints

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Mr. Stevens Rice
University Microfilms
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Specialization in bearings enables us to apply to your bearing problems an unmatched engineering talent and experience in powder metallurgy. You benefit, too, from outstanding manufacturing facilities, including the world's largest inventory of dies. Whatever your need, when it's bearings, see the bearing specialists . . . see Bound Brook.

Circle 401 on Page 19

**BOUND BROOK**

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*Circle 404 on Page 19*

**ROSS OPERATING VALVE COMPANY**

109 EAST GOLDENGATE AVE. • DETROIT 3, MICHIGAN



A three-deck 48" SWECO Separator used by a prominent chemical company in screening granular alkali to exact sizes. Using Marman quick-opening couplings, screens are easily changed to obtain any desired product size.



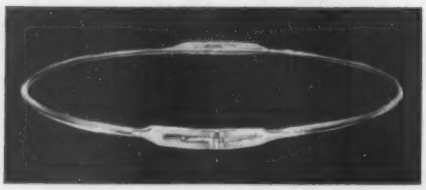
# "We Use MARMAN Couplings for Easier Screen Changes on SWECO Separators"

**Reports R. J. McCausland, Chief Engineer, Vibro-Equipment Division, Southwestern Engineering Company of Los Angeles**

SWECO Separators are used throughout industry for fast, efficient and economical screening of food, chemicals, sand and gravel.

For years, Southwestern has relied on Marman's line of Band Couplings to join Separator components because they reduce assembly costs. Marman's "quick-coupler" latch design makes servicing easy and cuts labor by permitting rapid screen changes for users of SWECO Separators.

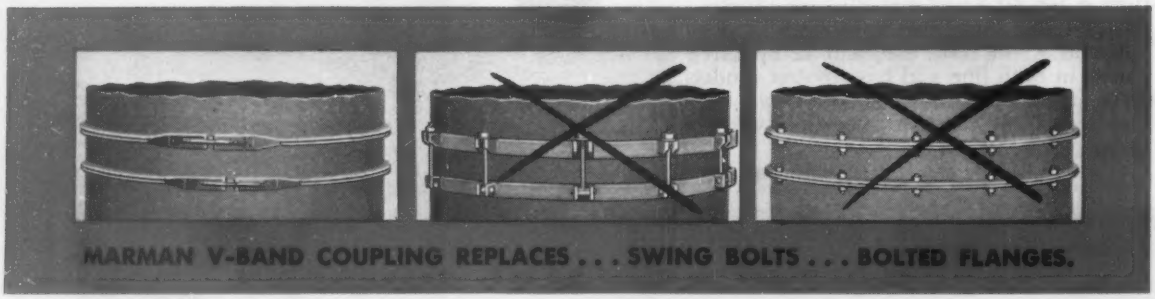
Marman has the coupling designs and experience to help solve almost any clamping, holding or fastening problem for manufacturers using any type of container, filter or similar device. Outline your requirements to us, or write today for full information about Marman's complete line of clamps, straps, couplings and joints.



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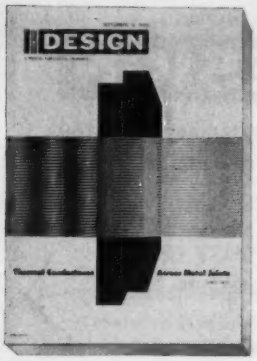
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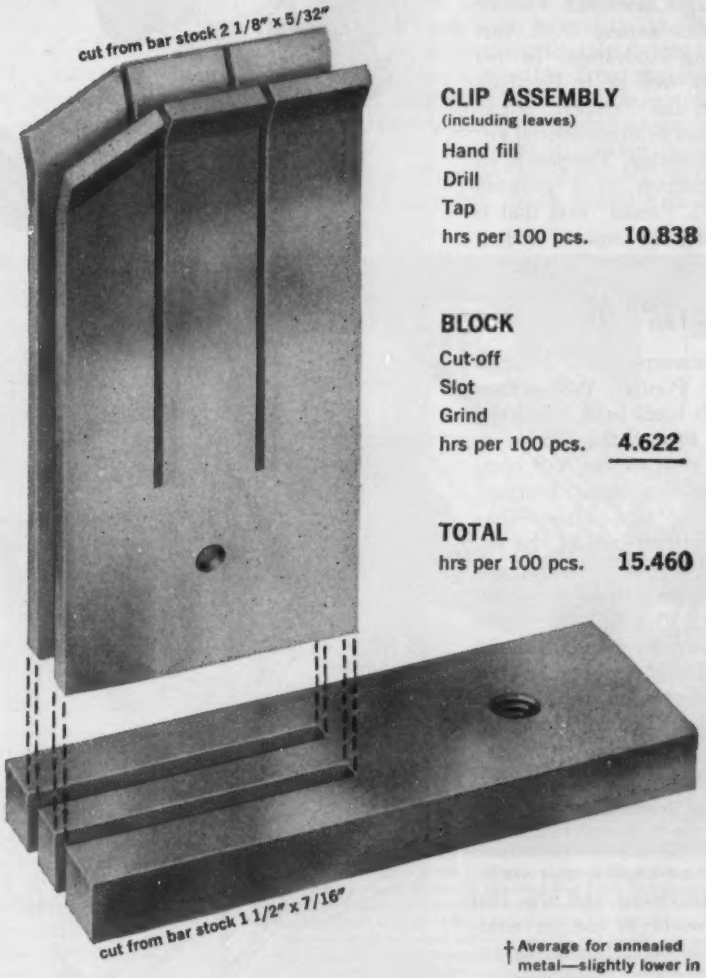
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# High electrical conductivity PLUS machining savings like this — with Anaconda Leaded Copper-126

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|---|---|---|---|
| **CLIP ASSEMBLY** (including leaves) | | **CLIP ASSEMBLY** (including leaves) | |
| Machine fill* | | Hand fill | |
| Drill | | Drill | |
| Tap | | Tap | |
| hrs per 100 pcs. | 4.310 | hrs per 100 pcs. | 10.838 |
| **BLOCK** | | **BLOCK** | |
| Cut-off | | Cut-off | |
| Slot | | Slot | |
| Grind | | Grind | |
| hrs per 100 pcs. | 2.641 | hrs per 100 pcs. | 4.622 |
| **TOTAL** | | **TOTAL** | |
| hrs per 100 pcs. | 6.951 | hrs per 100 pcs. | 15.460 |




*Parts are assembled, pin drilled, and pinned on a semiautomatic machine. Machine does not operate satisfactorily with Electrolytic T.P. Copper.

†Average for annealed metal—slightly lower in hard tempers

***55% SAVING in production time PLUS savings in longer tool life—cutters, 400%—drills, 33%—taps, 33%.***

Scores of electrical components made by Barkelew Electric Mfg. Co., Middletown, Ohio, specialists in the manufacture and development of high-capacity switching equipment for over 50 years, require high electrical conductivity in service and considerable machining in manufacture. The figures above for a clip assembly typify the savings made possible by the use of Anaconda's high conductivity Leaded Copper-126. Other applications include pieces machined from bar stock as large as 4½" x 2". Leaded Copper-126 is available in standard mill forms. For more information, see your Anaconda representative – or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6651A

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*Made by The American Brass Company*

## Cast-Iron Four Will Power Pontiac's Compact Tempest

LAST year, Chevrolet's Corvair set the pace among U. S. cars for engineering innovation. In '61, the prize may well go to Pontiac's new compact, the Tempest. Boasting several firsts in international automotive engineering, Tempest is an impressive addition to a growing stable of U. S. "small" cars that is rapidly curbing the imports' sizzling sales pace.

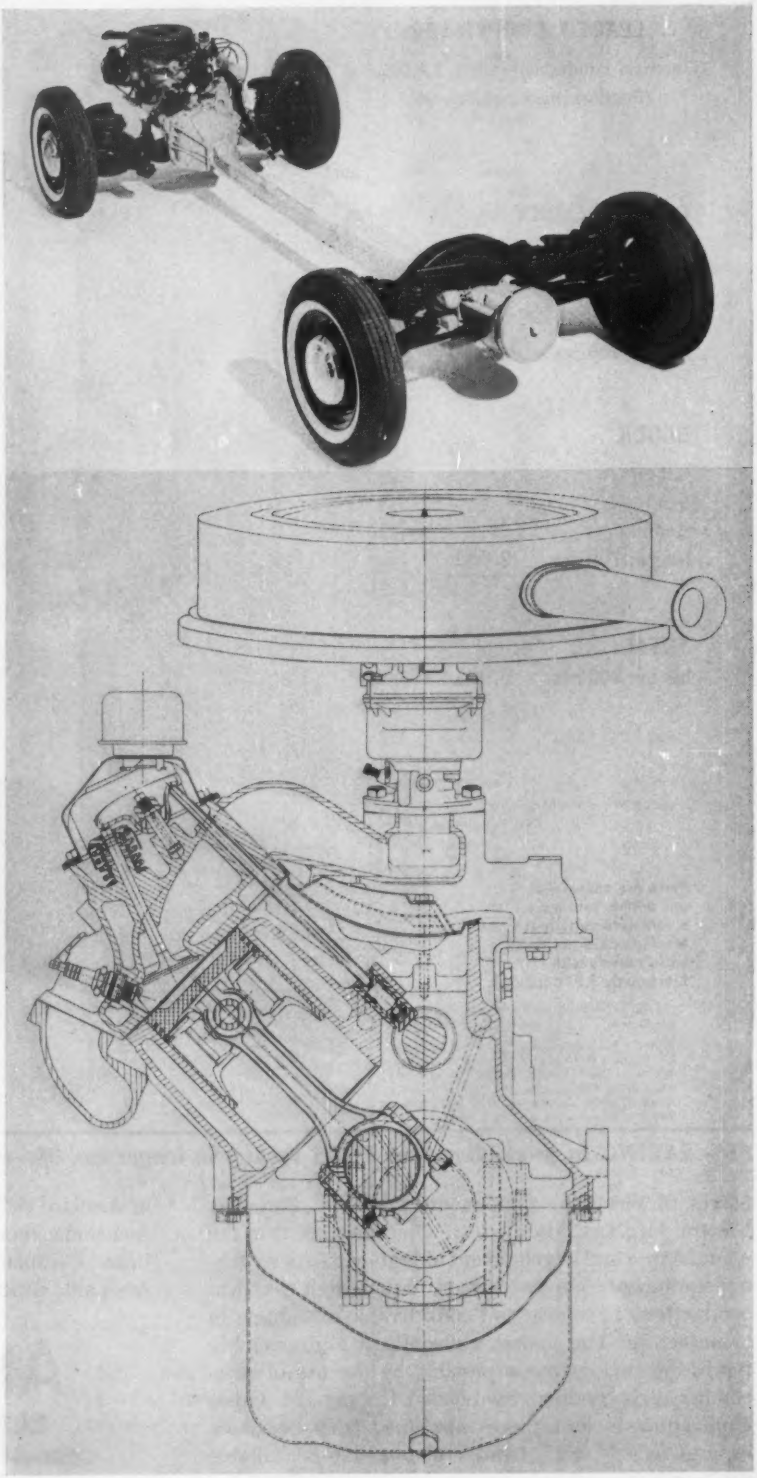
### Return of the Four

Standard powerplant for Tempest is a regular Pontiac V-8 engine, minus the left-hand bank. Inclined naturally at 45 deg, the 195 cu in. four retains most of the V-8 components, including main bearings, pistons, valves, and lifters (hydraulic). Two versions of the engine will be offered: An optional premium-fuel job (10.25 to 1 compression ratio) with four-barrel carburetion and the standard model with single-barrel carburetion and 8.6 to 1 compression ratio. Also available is a 215 cu in. aluminum water-cooled V-8 engine.

### New Angle in Driveshafts

Tempest is the first American car to have a front-engine, rear-transmission arrangement and the first car in the world to use an automatic transmission in this configuration.

Key to this unusual design concept is a $\frac{5}{8}$ in. diameter flexible propeller shaft which passes under the car, virtually eliminating floor hump. Made of forged steel, heat treated and shot peened for high



**Ideal weight distribution** is the important result of Tempest's front-engine, rear-transmission arrangement (above). Torque tube running through the center of the car joins the two components. The L-4 engine, one-half of Pontiac's conventional V-8, has a natural cant, permits low hood line.

# ...Fluid Power news

**REPORT NO. 12,107**
***HYTAC**** **AIDS MAKING OF NEW EXTENSIBLE PAPER**

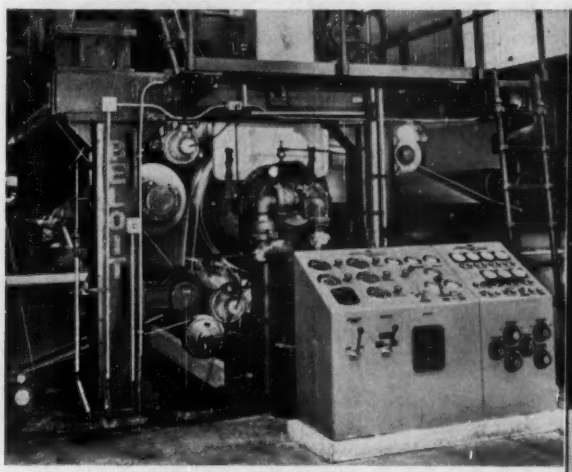
From Oilgear *Application-Engineering* Files

## HOW *HYTAC** SYSTEMS CONTROL NEW EXTENSIBLE PAPER MACHINE SECTION SPEEDS IN 12 MILLS

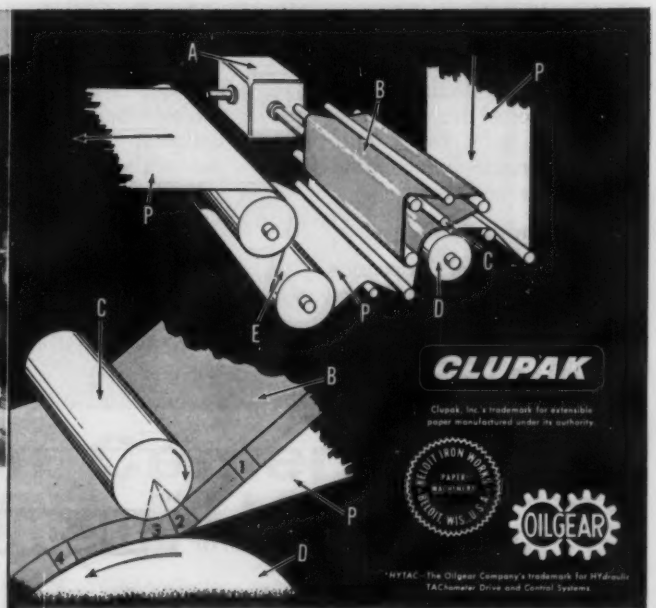
**USERS:** *Twelve Paper Companies—Licensed by CLUPAK, INC.*

Builder—Sections and Differential Drives—Beloit Iron Works, Beloit, Wisconsin

**DATA:** Systems to vary and precisely control speed and draw of new sections that can be an integral part of complete, new paper machines, or inserted into existing machines for production of CLUPAK® extensible paper—a revolutionary, patented, smooth, tough, kraft sheet. Original requirements called for systems that, when applied to *Beloit* mechanical differentials, would: *1.* Provide precision-controlled, infinitely variable section speed decrease up to 10% under main lineshaft speed—as selected from remote pushbutton stations. *2.* Maintain selected section speed within ±0.25% max. variation over a 50% load change at max. lineshaft speed. *3.* Be: compact; impervious to heat, high humidity; thrifty on electrical power input, wiring, installation downtime, floor space; completely free, if possible, from maintenance-provoking belts, chains, relays. *4.* Insure trouble-free, continuous, heavy-duty, full-production paper machine drive service—but permit section immobilization for production of non-extensible stock. *5.* One source and responsibility for these speed and draw controls preferred.



One of the most recent of the twelve new **Beloit** extensible sections and control consoles incorporating **HYTAC* SYSTEMS** for precise speed and draw control—as installed on No. 1 machine at **International Paper Company's Southern Kraft Division Mill, Camden, Arkansas,** to produce CLUPAK® extensible paper. Control console instrumentation includes direct-reading hydraulic pressure gages from the **OILGEAR System** to provide operators with constant, visual, exact indication of load or draw on the section.




**HOW IT WORKS:** Section driven by Oilgear-equipped **Beloit** differential (A), consists of a 1-in. thick natural rubber Blanket (B) operating over 3 rolls, and between Nip Roll (C) and steam-heated, polished, chrome plated Dryer Drum (D). Paper (P) is held between Blanket (B), slipping against Dryer Drum (D). Enlarged view at Nip Roll shows how normal (1) Blanket (B) is compressed (2), squeezed and elongated (3), and rapidly contracts (4) after leaving Nip Roll—shrinking paper. Normal production shrink requirement is accurately controllable up to 15% by controlled variation in nip pressure, moisture content, dryer drum temperature. Accurate control of draw in and between extensible unit and 3rd Dryer Section (E) is required regardless of load changes . . . a reason for the precise, infinitely variable speed-draw control provided by Application-Engineered **HYTAC* Systems.**

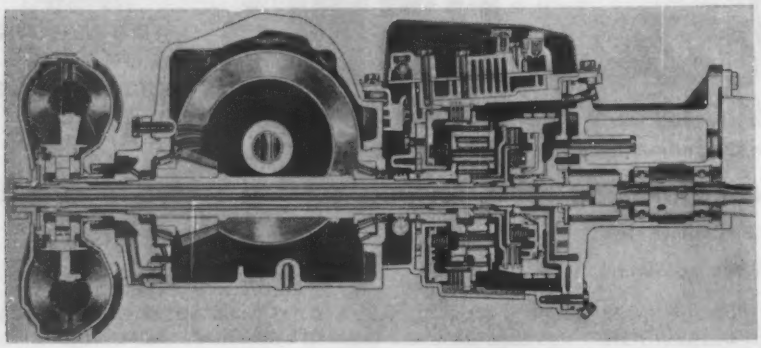
**SOLUTION:** Application-Engineered *HYTAC** (HY*draulic* TAC*hometer*) controlled differential drives consisting of Oilgear "DRt-3517" Variable Displacement Pumps, "H-6017" Constant Displacement Motors, and *HYTAC** components with remote pushbutton control to provide precise speed-draw control on *Beloit* extensible sections installed and commercially producing CLUPAK® extensible paper at nine mills in the United States, two in Canada, and one in Sweden. Several other paper manufacturers licensed by CLUPAK, Inc., to produce extensible paper under its authority, now have these Oilgear-equipped *Beloit* extensible sections on order. Oilgear *HYTAC** Drive-Control Systems were selected after 3 years of development on this process and machine—from a 2-in. table model, through a 15-in. laboratory model, and a 60-in. pilot model—as best suited to provide the accuracy and range of control required for the variable speed drives. *Actual commercial operation has proved that these highly accurate, compact, heavy-duty, Oilgear Systems can maintain any selected section speed with less than ±0.25% variation* regardless of load change *over a 10:1 range of lineshaft rpm—plus enabling operators to infinitely vary each section's drive rpm up to 15% under main lineshaft rpm . . . exceeding originally specified requirements!*

Circle 407 on Page 19

Other inherent Oilgear "Any-Speed" Drive features are: cushioned, controlled starting, acceleration, deceleration, braking . . . positive, automatic overload protection . . . continuously filtered pressure and flood lubrication. Copies of Oilgear's *Fluid Power NEWS* 3, 5, 8, 9, 11—with detailed descriptions of some of these and other *Application-Proved* installations are available on request.

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**Torque converter is aft of the main transmission assembly** (they are separated by the differential carrier) in Tempest's automatic transmission. The three-element torque converter — two-speed planetary arrangement with automatic upshift — is the first to use a "split-torque" principle. In high gear, the drive is approximately 40 per cent straight mechanical, with 60 per cent of the torque going through the converter. Shift-selector lever is mounted on the car's instrument panel. It provides positions for reverse, neutral drive, and low.

fatigue life, the shaft is housed in a hat-sectioned steel torque tube that rigidly joins the engine and transmission. The shaft's curved housing supports the necessary bearings and, as a happy side effect, divorces engine-torque reaction from the engine mounts.

### *Another Swing Axle*

Tempest's rear suspension (like Corvair's) is designed around a swing axle. The suspension system's main cross member attaches to the car's unit body in four places; transaxle is suspended from the cross member. Differential and final drive gear case are thus mounted to the sprung mass of the car, axle shafts being driven through universal joints on either side of the differential. U-joints have splined yokes which extend into the side gears of the case.

Standard transmission on the car is a manual-shift, three speed synchromesh; a two-speed automatic is optional. The synchromesh shares a common lubrication system with the rear axle.

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And in 1961 there'll be four more: *The SEALS Book . . . The BEARINGS Book . . . The FERROUS METALS Book . . . The ELECTRIC MOTOR Book*

See Page 207 for more details

# Topics

**Alchemy, 1960 style,** reports progress in turning ammonia into a rocket fuel. Aerojet-General Corp. is working on a method of nuclear bombardment, called fissio-chemistry, which will produce hydrazine from liquid ammonia. Hydrazine, composed of two parts nitrogen and four parts hydrogen, has the unusual and desirable characteristic of storability. Other liquid rocket fuels cannot be kept on the shelf.

• • •

**Early to rise:** Engineers who live and work in the vicinity of Santa Clara, Calif., can take advantage of classes at the local university, held between 7:00 and 9:00 a.m.

• • •

**Neater, less noisy building razing** results from a new method developed by Linde Co., division of Union Carbide Corp. The "powder-lancing" technique uses burning powdered metals to cut through building walls quickly and without vibration. Hoses feed oxygen and iron and aluminum powder through a pipe; the mixture ignites when the end of the pipe is heated with a welding torch. Heat of the flame and abrasion from the alumina and iron oxide particles will cut through concrete and other ferrous and nonferrous materials.

• • •

**A human conductor** transmits electricity to operate a control system recently patented by United Shoe Machinery Corp. To activate a machine which applies hydraulic pressure to the sole of a shoe, the operator grasps two controls simultaneously, thereby transmitting an imperceptible current. Protection from lightning, power leaks, and resistance failures is provided.

• • •

**Synthetic rubber making** bounces around the world. Five years ago, the U. S. produced the entire world's supply of synthetic; this year's 1 6 million tons will be only half of total production.

• • •

**The Saturday night bath** and Monday washday, two down-to-earth customs, seem destined for nonobservance in space. Problems of water supply and energy rule out anything more than a water-alcohol sponge bath and will not permit any laundry activity. Instead, disposable suits made of lightweight, absorbent paper will probably be worn, according to Rollin Gillespie, research scientist at Lockheed's Missiles and Space Div. Mr. Gillespie expects the garb to resemble pajamas or long underwear, but—since even the early space-suit market will probably include women—it can be made "stylish" through unlimited use of color.



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Normal-Standard Medium Duty PILLOW BLOCKS



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Circle 408 on Page 19

# LD-BLC

## . . . formula for long-range flight

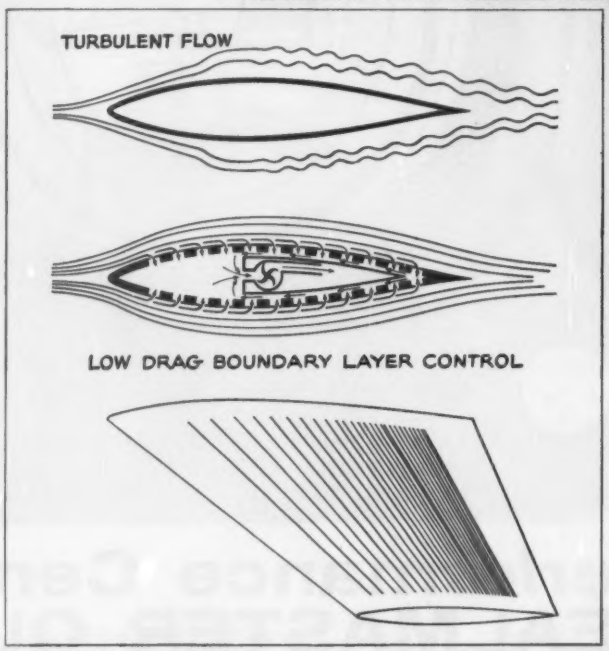
**WASHINGTON—Air Research and Development Command will spend $20 million proving out a revolutionary technique for taming turbulent skin friction on aircraft. Called LD-BLC (for low drag boundary layer control), the new suction-slot method holds smooth laminar flow over flight surfaces at Reynolds numbers up to 36 million. The developer, Northrop Corp., says resulting low drag coefficients may double range or duration of subsonic and supersonic aircraft.**

In the ARDC-Northrop technique, turbulent boundary-layer air is drawn through slots in the aircraft skin by a suction compressor, then exhausted aft through fuselage or nacelle tailpipes. Extensive wind-tunnel and flight tests on a test F-94, modified with a slotted "glove," have proved that LD-BLC will hold full laminar flow over a wide range of speeds, cut skin-friction drag as much as 80 per cent.

Northrop scientists predict that the technique will expedite the development of nuclear-powered aircraft. Since laminar flow means low drag, reaction powerplants can be smaller, and nuclear aircraft will require less shielding for crew and payload. Consequently, a lighter airplane will result.

The developers point out that LD-BLC is a unique development, one designed to boost flight range or endurance, or to permit design of smaller aircraft for a given mission. Northrop says it should not be confused with boundary-layer-control hardware that provides high-lift performance in landing and takeoff.




**Skin-friction coefficients zoom** when a laminar boundary layer turns turbulent (photo, top). Multiple spanwise slots in the ARDC-Northrop system (sketches) remove the turbulent film, extend the low-drag laminar-flow region over the full wing chord. Developed under the direction of Dr. Werner Pfenninger, Norair's LD-BLC culminates a 10-year study.

## Continuous Heat Treating Toughens Thin Plates

PITTSBURGH—A completely modernized strip mill will soon turn out high-yield strength steel quenched and tempered. Announcing that U. S. Steel Corp. can now produce thin-gage sheet and strip from some of the toughest steels known to man, R. F. Sentner, vice president, said: ". . . the way is open for the creation of stronger, yet lighter-than-ever designs in new commercial, industrial, and military applications."

Formerly available only in plate 3/16 in. thick and more, the new thin steels are heat-treated (quenched and tempered) grades for application where extreme strength and toughness are needed:

- Equipment for processing and handling liquefied gases.
- Highway, rail, and marine transport equipment.
- Strong, lightweight, highly mobile military items.

As an example of the weight that can be saved, U. S. Steel points to the 16,000 lb trailer used to launch the Army's Sergeant missile. Thin sheets of "T-1" constructional alloy steel, having three times the yield strength of structural carbon steel, were used to fabricate various frame and superstructure components for the launcher. A weight-saving of 7000 lb resulted.

PRODUCT INFORMATION





N/D sound booth for analysis of electric motor noise, mounted on springs and constructed with non-parallel walls, assures manufacturers a *scientific solution* to electric motor noise problems. Motors are tested with special electronic sound evaluation equipment.

# How N/D Minimizes Electric Motor Noise!

In New Departure's full-time noise analysis program, a unique sound booth and special electronic sound level equipment are used to pinpoint and evaluate electric motor noise. Inside the booth, a condenser microphone picks up air-borne noise from the running motor. Outside, the signal is electronically registered and recorded.

By changing one variable at a time, such as bearing or mounting design, or lubricant, N/D engineers are able to select the proper combination that results in the quietest motor operation. That's why you'll find New Departure precision ball bearings specified for electric motors to be used in quality home appliances, instruments, fans, hand tools and other applications . . . for greater consumer sales appeal.

If you have an electric motor noise problem, contact the N/D Sales Engineer in your area. For additional information call or write New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE

BALL BEARINGS

*proved reliability you can build around*

## Planning in Final Stages for Mechanisms Conference

WEST LAFAYETTE, IND.—Final details are being arranged for the Sixth Conference on Mechanisms to be held on the campus of Purdue University, October 10 and 11. Believed to be the only organized meeting of its kind in this country, the Conference is devoted to methods and systems for the design and development of mechanisms; practical applications and uses of cams, linkages, and gearing; and production considerations and limitations.

This year, a select program of 17 papers will be presented by recognized mechanisms specialists during the two-day session. This represents one of the largest and most comprehensive programs in Conference history and points to the continuing growth and interest enjoyed by the Conference since its inception a relatively short time ago.

A feature of this year's program will be a special presentation by Prof. W. L. H. Schmid at the Conference luncheon on Tuesday, October 11. Professor Schmid is dean of mechanical engineering, Technological University of Eindhoven, Eindhoven, Netherlands, a position he has held since the University first opened its doors in 1957. Under his guidance, the theory and construction of mechanisms have received special attention in the engineering curriculum and in the expanding research programs being carried out by the new University. Professor Schmid has also served on the faculty of the Technological University of Delft, where he received his degrees (M.E.; PhD). His background in education is well supplemented with experience in industry.



**Scene of the forthcoming Mechanisms Conference,** Purdue University's Memorial Center will be the meeting place for a distinguished group of foreign and American mechanisms experts. Co-sponsored by MACHINE DESIGN and Purdue's School of Mechanical Engineering, the Conference is designed to appeal to working engineers in all phases of industry.

Regular attendees of the Conference will remember Dr. Rudolf Beyer, prominent German kinematician, who presented a paper on space mechanisms at the last Conference. Dr. Beyer will present another paper on the same subject on Oct. 11.

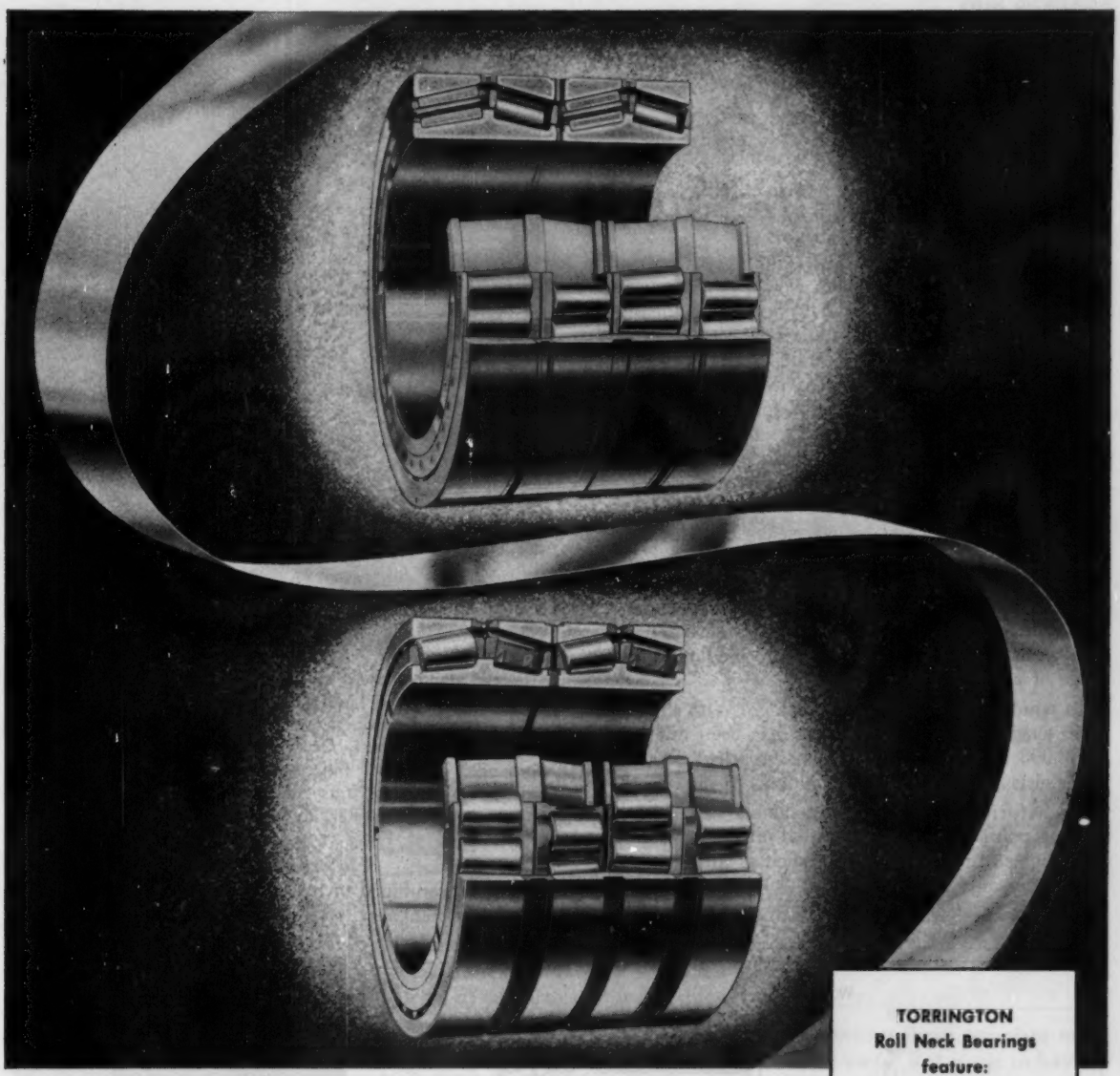
Abstracts of all Conference papers appeared in the last issue (Sept. 1) of MACHINE DESIGN. The complete program and an advance registration and room-reservation form appear on Page 314 of this issue.

For any additional information, write or call K. E. Glancy, Division of Adult Education, Purdue University, Lafayette, Ind.

## SLAR is for Radar, Sideways




**Equipped with side-looking-airborne radar,** Grumman Aircraft's AO-1 Mohawk can snap a permanent aerial radar map of terrain on either side of the airplane flight path. An in-flight processor enables the observer to see a developed photograph seconds after the 4 x 5-in. cut film or 70-mm strip film is exposed. Despite its awkward appearance and size, SLAR gear does not affect the aircraft's aerodynamic qualities, according to Grumman engineers. Powered by two Lycoming T-53L engines delivering 1005 eshp, Mohawk weighs just over 9000 lb (empty), has a 42-ft wingspan, and is 41 ft long. Army has ordered 77 of the craft to extend its surveillance capabilities.



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**Roll Neck Bearings**
**feature:**

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- advanced heat treatment
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- resistance to shock loads
- precision manufacture
- grooved cone faces

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*Circle 410 on Page 19*

## New electric-arc machine will heat air to temperatures

# *Hotter than the Sun*

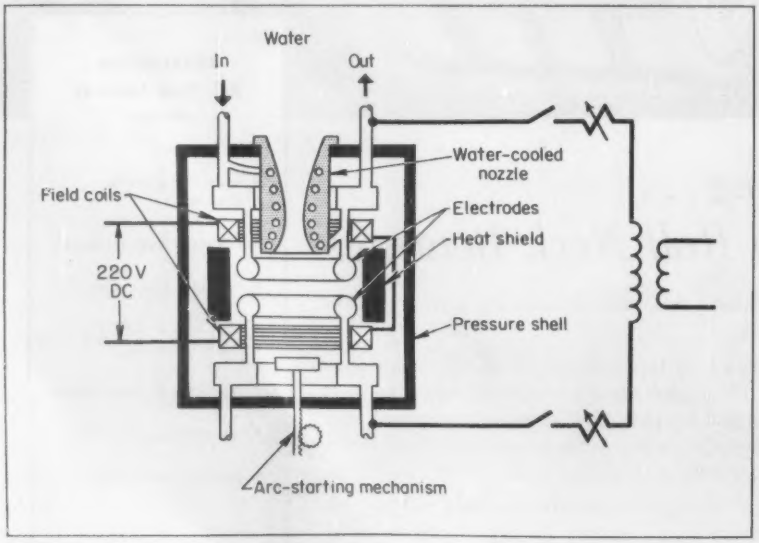
DISSIPATING megawatts of power, a new electric-arc heater designed and built by Westinghouse is the prototype for off-the-shelf units that may eventually generate continuous gas flows at 20,000-F temperatures and pressures to 15,000 psi. Key to the design is a rotating arc that can be maintained for periods up to 10 min without eating away electrodes or chamber walls. Calculations show that contaminants added to the gas stream will be less than 0.2 per cent at design input (30,000 kw in the prototype).

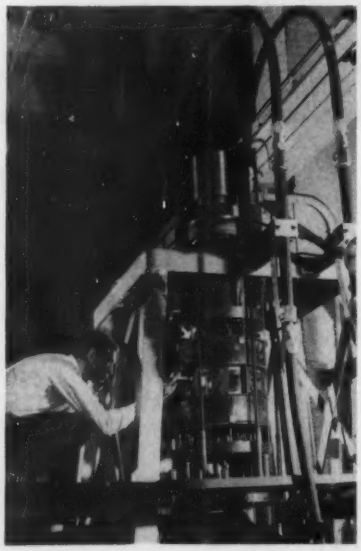
Testing programs are by no means completed since the prototype has not been operated anywhere near maximum design condition (highest input to date is 1700 kw). However, performance has proved so satisfactory that Westinghouse engineers are designing production models of small units and are predicting a wide range of applications:

- In wind tunnels, for missile testing. With the prototype, temperature into the nozzle has been maintained at 10,000 F and flow velocity has reached 3400 mph. Later tests call for velocities as high as Mach 10.
- As a furnace, for processing metals with ultrahigh melting points. In this application, the unit would produce ingots of refractory metals such as tungsten, available today only in powder form.
- As a chemical synthesizer, for inducing difficult chemical reactions. For example, nitrogen and oxygen could be combined in the heat chamber to form nitrous oxide—a compound widely used in chemical processing.



**Hollow, donut-shaped electrodes** terminate the arc. Shown removed from the heater, but in correct relative position, the electrodes survive erosion effects for two reasons: 1. They are continuously water cooled. 2. The arc is rotated around the gap at high speed by a magnetic field. In the prototype unit, gases heated by the arc have been maintained at 10,000 F, as hot as the sun's surface.



**Working fluids,** such as air or nitrogen, pass into the arc through openings near the heat shields. After heating, gases exit through a hypersonic exhaust nozzle. Although efficiency of heat transfer between arc and gas is high—about 50 per cent—most of the parts (including electrodes, heat shields, and exhaust nozzle) are water cooled. To further cool the electrodes, dc coils set up a magnetic field that rotates the arc at high speed around the gap. Prototype unit, shown with the pressure shell removed, right, has already gone through about 50 tests and many more are planned. Highest chamber pressure to date is 730 psi; highest flow rate is 0.687 lb per sec. Westinghouse expects to have production heaters (1500 psi, 1.2 lb per sec, 10,000 F) available in the immediate future.

## Solid-State Transducer Needs No Amplifier

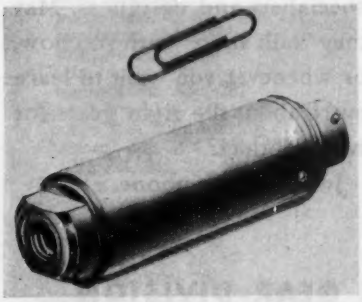
HICKSVILLE, N. Y.—Best characteristics of strain-gage and potentiometer transducers, but none of the disadvantages of either, are claimed to be combined in a new kind of pressure transducer.

Developed by Fairchild Controls Corp., the solid-state strain-gage transducer (hence, the name 3S-G) pioneers a new line that will produce high-level dc outputs (to 5 v) and do away with the need for signal amplification and impedance matching. In addition, it's an extremely accurate device—better than 0.1 per cent linearity and hysteresis. Pressure ranges are 0-100 to 0-10,000 psi.

Other unique advantages include:

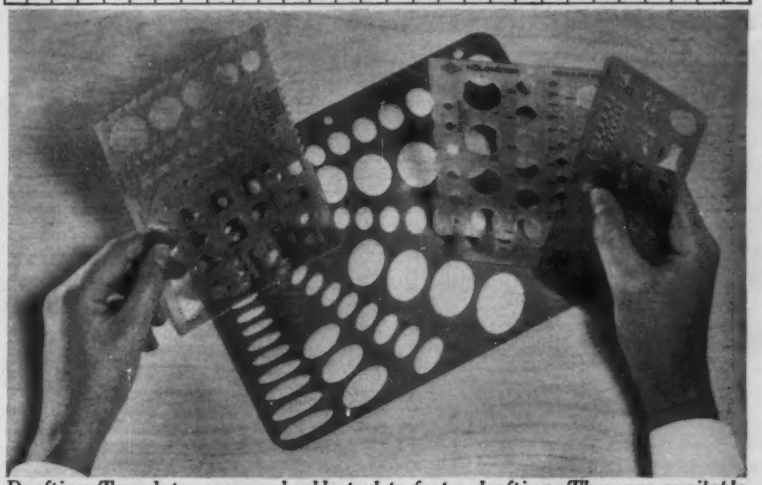
- Extreme simplicity (only two mechanically functioning parts).
- Accurate response to both static and dynamic pressures.
- Full compatibility with existing military and industrial systems.
- Superior linearity, hysteresis, and environmental characteristics.
- Accuracy unaffected by rough handling or severe environments.

Although the development program took less than a year, Fairchild engineers had to solve fundamental problems in semiconductor materials: Microminiature elements had to have high resistance and be independent of temperature; semiconductor sensing elements had to be economically matched in large production quantities; and the complete circuitry had to be capable of withstanding military environments.



**Lightweight and small,** Fairchild's solid-state transducer weighs 5 oz, measures 3 in. by 1⅛ in. diam. Because maximum output is about 5 v, the device does not need amplifiers.

# DRAFTING TRENDS



*Drafting Templates are a valuable tool to faster drafting. They are available in an almost endless variety.*

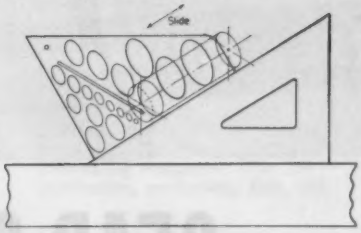
## Specialized drafting templates speed drawing time

Always a handy tool, drafting templates are becoming increasingly in use to simplify everyday drawing techniques. Now vinyl plastics are used in the manufacture of the majority of templates. But the thickness, color and finish vary in almost endless profusion. Glare-saving colors, such as green and amber, are usual, both in clear and matte finishes. However, the white and clear plastics still are popular. The thicknesses vary with the different types of available templates from .020 gauge through .070 gauge.

### Specialized template applications

A list showing the growing application for templates includes templates for: Electronic Symbols, Electrical Wiring, Landscaping, Screw Heads, House Plans, Nuts and Bolts, Screw Threads, Tooling, Windows, Plumbing, Mathematical Symbols, Map Planning, and many "all-purpose" templates for circles, ellipses, triangles, and other shapes.

### Isometric ellipse template is a big timesaver




An isometric ellipse template may be more useful if it is cut in half to provide edges parallel to the minor axes of the ellipses. Halves of the template may then be moved along a 30-60 degree triangle so that ends of a shaft or any cylindrical shape can be drawn in a minimum of time and in perfect alignment.

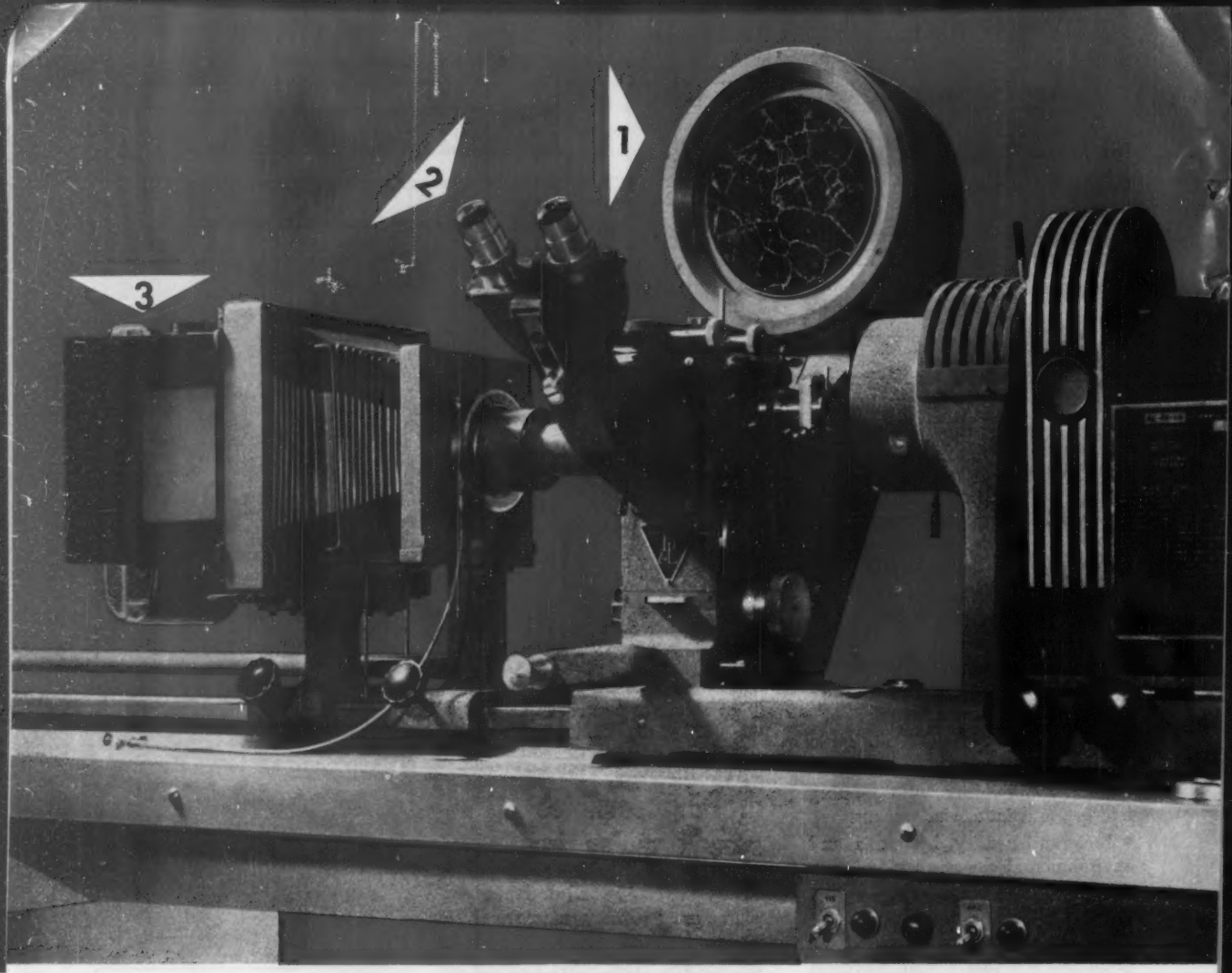
A selection of 52 popular templates is illustrated and described in a special six page brochure, "Drafting Templates" recently published by Frederick Post Company. *For your copy, write Frederick Post Company, 3652 N. Avondale Ave., Chicago, Illinois.*

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Circle 411 on Page 19




# GEAR STEEL has no secrets here

This instrument provides three ways to examine the micro structure of steel.

1. *View it on the screen.*
2. *Examine it through a microscope.*
3. *Then take its photo for a permanent record.*

Thus, chemical constituents can be analyzed, hardness patterns detected, and precise control of heat treatment can be determined.

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GEAR-MAKERS TO LEADING MANUFACTURERS

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## USE A YELLOW CARD *for More Information . . .*

**CIRCLE ITEM NUMBERS**—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

**EDITORIAL CLIPSHEETS**—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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**Sept. 15, 1960**

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| 402 | 432 | 462 | 492 | 522 | 552 | 582 | 612 | 642 | 672 | 702 | 732 | 762 | 792 | 822 | 852 |
| 403 | 433 | 463 | 493 | 523 | 553 | 583 | 613 | 643 | 673 | 703 | 733 | 763 | 793 | 823 | 853 |
| 404 | 434 | 464 | 494 | 524 | 554 | 584 | 614 | 644 | 674 | 704 | 734 | 764 | 794 | 824 | 854 |
| 405 | 435 | 465 | 495 | 525 | 555 | 585 | 615 | 645 | 675 | 705 | 735 | 765 | 795 | 825 | 855 |
| 406 | 436 | 466 | 496 | 526 | 556 | 586 | 616 | 646 | 676 | 706 | 736 | 766 | 796 | 826 | 856 |
| 407 | 437 | 467 | 497 | 527 | 557 | 587 | 617 | 647 | 677 | 707 | 737 | 767 | 797 | 827 | 857 |
| 408 | 438 | 468 | 498 | 528 | 558 | 588 | 618 | 648 | 678 | 708 | 738 | 768 | 798 | 828 | 858 |
| 409 | 439 | 469 | 499 | 529 | 559 | 589 | 619 | 649 | 679 | 709 | 739 | 769 | 799 | 829 | 859 |
| 410 | 440 | 470 | 500 | 530 | 560 | 590 | 620 | 650 | 680 | 710 | 740 | 770 | 800 | 830 | 860 |
| 411 | 441 | 471 | 501 | 531 | 561 | 591 | 621 | 651 | 681 | 711 | 741 | 771 | 801 | 831 | 861 |
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| 415 | 445 | 475 | 505 | 535 | 565 | 595 | 625 | 655 | 685 | 715 | 745 | 775 | 805 | 835 | 865 |
| 416 | 446 | 476 | 506 | 536 | 566 | 596 | 626 | 656 | 686 | 716 | 746 | 776 | 806 | 836 | 866 |
| 417 | 447 | 477 | 507 | 537 | 567 | 597 | 627 | 657 | 687 | 717 | 747 | 777 | 807 | 837 | 867 |
| 418 | 448 | 478 | 508 | 538 | 568 | 598 | 628 | 658 | 688 | 718 | 748 | 778 | 808 | 838 | 868 |
| 419 | 449 | 479 | 509 | 539 | 569 | 599 | 629 | 659 | 689 | 719 | 749 | 779 | 809 | 839 | 869 |
| 420 | 450 | 480 | 510 | 540 | 570 | 600 | 630 | 660 | 690 | 720 | 750 | 780 | 810 | 840 | 870 |

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**Sept. 15, 1960**

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| 241 | 421 | 451 | 481 | 511 | 541 | 571 | 601 | 631 | 661 | 691 | 721 | 751 | 781 | 811 | 841 |
| 242 | 422 | 452 | 482 | 512 | 542 | 572 | 602 | 632 | 662 | 692 | 722 | 752 | 782 | 812 | 842 |
| 243 | 423 | 453 | 483 | 513 | 543 | 573 | 603 | 633 | 663 | 693 | 723 | 753 | 783 | 813 | 843 |
| 244 | 424 | 454 | 484 | 514 | 544 | 574 | 604 | 634 | 664 | 694 | 724 | 754 | 784 | 814 | 844 |
| 245 | 425 | 455 | 485 | 515 | 545 | 575 | 605 | 635 | 665 | 695 | 725 | 755 | 785 | 815 | 845 |
| 246 | 426 | 456 | 486 | 516 | 546 | 576 | 606 | 636 | 666 | 696 | 726 | 756 | 786 | 816 | 846 |
| 247 | 427 | 457 | 487 | 517 | 547 | 577 | 607 | 637 | 667 | 697 | 727 | 757 | 787 | 817 | 847 |
| 248 | 428 | 458 | 488 | 518 | 548 | 578 | 608 | 638 | 668 | 698 | 728 | 758 | 788 | 818 | 848 |
| 249 | 429 | 459 | 489 | 519 | 549 | 579 | 609 | 639 | 669 | 699 | 729 | 759 | 789 | 819 | 849 |
| 250 | 430 | 460 | 490 | 520 | 550 | 580 | 610 | 640 | 670 | 700 | 730 | 760 | 790 | 820 | 850 |
| 401 | 431 | 461 | 491 | 521 | 551 | 581 | 611 | 641 | 671 | 701 | 731 | 761 | 791 | 821 | 851 |
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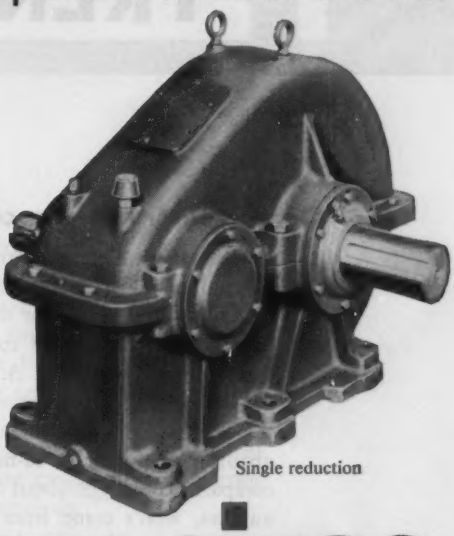
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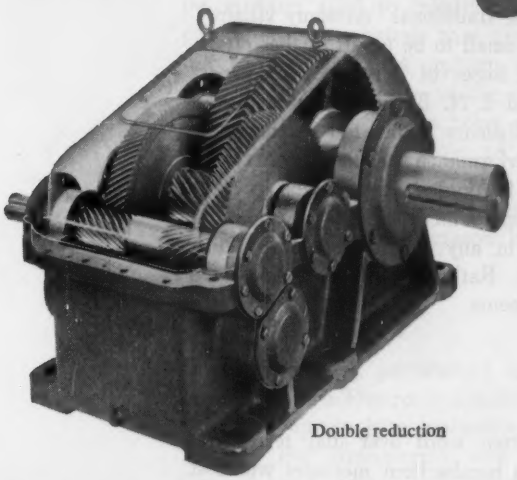
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**NOW** Link-Belt parallel shaft speed reducers offer

# new design



Single reduction



Double reduction

# new sizes

# new ruggedness



Triple reduction

## reduce drive costs by matching drive size to horsepower requirements with 50% more sizes

*New design*—Herringbone or double helical gears arranged in new "balanced" design permit high horsepower, high ratio reduction in a sturdy, compact housing.

*New sizes*—Now 20 sizes each of double and triple reduction units; 17 single. Drive selections closely match hp requirements, with a corresponding reduction in drive costs. Available to 2800 hp, ratios to 292:1.

*New ruggedness*—Rigid, ribbed housing keeps parts accurately and permanently aligned even under grueling operating conditions involving heavy shock loads, and temporary overloads.

For complete information call your nearby Link-Belt district sales office. Ask for Book 2719.

### OUTSTANDING FEATURES

- Grease-lubricated seals.
- Positive splash lubrication supplies ample flow of oil to all moving parts.
- High-capacity spherical roller bearings for maximum loading.
- Gears of hardened, precision alloy steel. Double helical or herringbone design.
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- Exceptional wearing qualities in accurately machined low-speed shafts of heat-treated carbon steel; intermediate shafts of chrome-molybdenum steel.
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## Carnot confronts the compacts

Fuel-economy sleuths—intrigued by the miles-per-gallon potential of the modern small-car engine—may find that some traditional "economy villains" either can't be helped, or they're already too small to be worth further effort. Tabulating part-throttle compact-car engine losses in a recent SAE paper, Ford Motor Company's A. E. Cleveland and I. N. Bishop conclude that a 20 per cent boost in present-day thermal efficiency is not out of the question. This would level out compact-car performance (at the flywheel) at about 65 mpg for a 40-mph clip. (With frictionless drive trains, present compacts could get about 34 mpg.) An improvement this big, caution the authors, won't come from a breakthrough in any single area—carburetor, distributor, combustion chamber, or valving. Rather, small losses will have to be whittled still further in many components.

## . . . so much better than a letter?

Instantaneous transmission of the handwritten word over dial telephones may make the postage stamp obsolete. The handwritten messages will cost no more than regular telephone calls, except for the cost of leasing the handwriting device. Although Comptometer Corp., Chicago, claims to produce the only Bell System-approved equipment, a newcomer, TelAutograph Corp., Los Angeles, expects its version of the device to be in use soon. Transmission of writing over private lines ($3000 per month between N. Y. and Calif.) has been possible for some time.

## private pentagons

Industry can no longer merely wait for defense agencies of the government to define the weapons that will be needed to defend the nation, says Dr. George L. Haller, General Electric Co. vice president and general manager, Defense Electronics Div. Far-sighted planning, necessary to research and development of modern weapons, demands that industry program its own future, Dr. Haller asserts. Based upon such planning, decisions can be made to explore some areas in future research and leave others alone. And as military defense becomes "just one of the several aspects of the total defense effort, this approach can do much to pave the way for the transition into greater nonweapons activity."

## the six sides of solid state

Solid-state technology is opening so many new doors that it's reasonable to speculate not even 10 per cent of the possible electronics applications have yet been conceived, reports Robert W. Galvin, president, Motorola Inc. The solid state offers the greatest single technical challenge faced by the electronics industry in the last 40 years. To compete effectively, a company must have broad and deep talents. At least six areas of intelligence are essential: Thin-film technology, semiconductor technology, electronic ceramics, incapsulation and surface-passivation techniques, systems disciplines, reliability and environmental evaluation methods.

## digital computer writes its own ticket

Graduate students at the University of Michigan are converting digital computers from aides to freethinkers. They're working on a new method of programing the digitals that rephrases the command "solve this problem this way" to "here's a problem, see what you can find out about it." Two programs are underway at the university. In the first, a system-simulator program, the computer is being taught to organize and develop a procedure for calculating performance of a physical system from general English-language descriptions. In the second, the computer produces analytical equations, or models, of phenomena. In effect, the programs are designed to give the computer a greater share in problem analysis.

## recruiters' sideshow

The no-recruiting gentlemen's agreement among companies attending the recent Western Electronic Conference (in Los Angeles) may lead to an entirely new approach to conference recruiting. Engineers attending WESCON reported the arrangement was completely effective—at the Arena. But Careers Inc., about a mile away, was doing a hustling business. Twenty-three firms had booths in the co-operative recruiting center, and almost 2000 engineers registered for new positions.

## man or machine in space . . . failure rate is important

Man's ability to complain, reason, and adapt eliminates the chance he'll be replaced by electronic counterparts, according to speakers at the recent Western Electronic Show and Convention. D. T. McRuer, president, and I. I. Ashkenas, vice president, of Systems Technology, Inc., Inglewood, Calif., agreed with the obvious axiom that a machine outperforms man when the task is specific and unchanging. But when the equipment fails, the human pilot can evaluate the situation and regain control. They pointed out that a human pilot fails gradually and gracefully, as compared to the sudden and complete failure of a mechanical component or system. Because of his ability to adapt and voice his opinion, man definitely plays the key role in plans to explore space, they concluded.

## NLRB tightens technician standards

National Labor Relations Board has consistently held that title alone does not make a man a technical employee. Last year, for example, in the *Litton* case, the Board decided that employees included in a technical unit must do work "of a technical nature involving the use of independent judgment and requiring the exercise of specialized training usually acquired in colleges or technical schools or through special courses." In the *Litton* case, use of independent judgment and nine months of trade-school education were held to be adequate for technical status. However, in a recent decision involving General Electric Co., the Board indicated a trend to higher educational requirements. In this case, only employees with two years or more of technical-institute training were ruled to be technicians.

# FOR RELIABILITY UNDER SHOCK LOADS AND HIGH HEAT...SPECIFY MIDVAC STEELS



Where metal parts must stand the sudden shock of heavy loads, as on plane landing gears . . . or the high heat of jet engines Midvac Steels offer the answer. The Midvac Process of consumable electrode vacuum melting produces metals with increased tensile, higher impact properties, improved stress rupture strength at elevated temperatures, and longer fatigue life.

Midvac Steels are offered in many alloys (some are shown in table below) as billets or forgings for the production of forgings to meet the most critical design specifications of today's space age. Complete details on Midvac Steels, plus comparative analysis of leading super alloys are available in new Midvac Steel Booklet. Write for your copy to . . .

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| Alloy | Melting Process | Yield Strength .2 | Ultimate Tensile Strength | Percent Elongation | Percent Reduction of Area |
|---|---|---|---|---|---|
| A-286 | Air Melt | 99,000 psi | 132,300 psi | 9.0% | 14.7% |
| | Midvac | 117,000 psi | 150,500 psi | 21.3% | 33.8% |
| D6A-C | Air Melt | 234,800 | 281,000 | 4.9% | 20.6% |
| | Midvac | 256,700 | 294,250 | 9.6% | 28.4% |
| Tricent | Air Melt | 238,600 | 284,500 | 6.1% | 19.7% |
| | Midvac | 254,300 | 291,600 | 10.3% | 25.6% |
| 901 Regular | Midvac | 116,000 | 160,000 | 18.0% | 25.0% |
| 901 Hi-Strength | Midvac | 131,000 | 179,000 | 19.2% | 20.2% |

Properties shown are averages of 25 heats

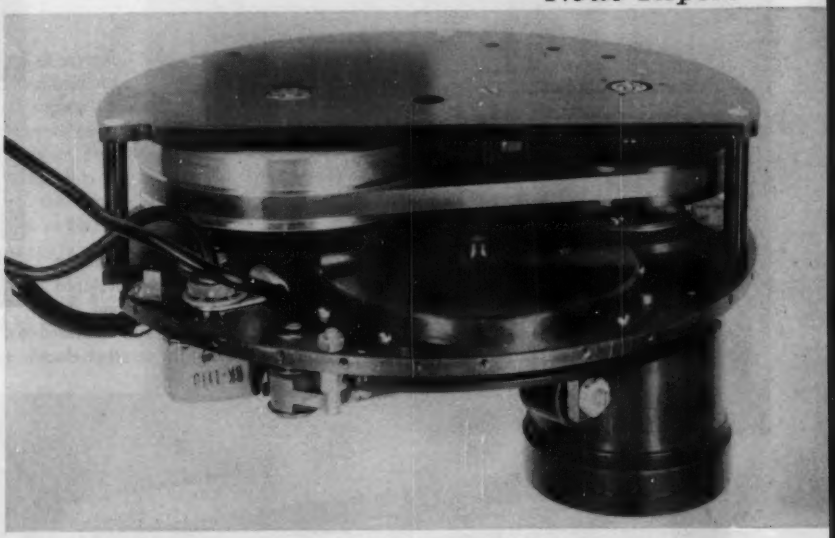
MH *Midvac Steels*



Circle 414 on Page 19

# Thin-Film Drive Belts

## *new dimension in power transmission*



DEVELOPED for space but sure to find many other power-transmission jobs, thin new polyester belts offer premiums in efficiency, compactness, and weight savings. The belts, developed by National Aeronautics and Space Administration, range in thickness from ½ to 10 mils, yet they tolerate high stresses and fatigue better than most conventional types.

According to NASA, the future of the new film belts seems especially bright for several reasons:

- Power transmission is uniform, due to exceptionally small variations in thickness—within 0.001 in., if necessary.
- Efficiency is high (up to 98 per cent) because the belts are extremely flexible and negligible force is needed to bend them over a small radius. The only significant power loss in a drive system occurs in the bearings (due to belt tension).
- Speed and torque capacities are high, because of high allowable stress and high strength-to-weight ratio of the polyester film.

Properties of the film give the belts some additional unique advantages. The material has high dielectric strength and surface resistivity. A high surface charge accumulates, and this charge can be used both to retain the belt in position and to restrain it from rubbing the driving pulley when declutched. Enough charge is developed for the job when the belt initially rubs against a magnesium driving pulley.

Tolerance to environmental temperature is exceptional. The material boasts high-temperature strength and only low internal friction occurs when it flexes over a pulley. Resistance to chemicals, solvents, and radiation makes the belts attractive in many special applications.

No failures have yet occurred, either in ground test or in flight programs, says John H. Licht, chief of NASA's mechanical instrumentation section, Goddard Space Flight Center, Washington. In the laboratory, the belts transmit power efficiently in machine-shop equipment: For example, a 5-mil belt is outperforming fabric-and-rubber types on a 1/12-hp, 22,500-rpm grinder.

High-power applications also seem practical; plans call for experiments with a 10-mil belt teamed with a 2-in. pulley and transmitting 10 hp at 3000 rpm. At the other end of the application spectrum, ½-mil belts have long lives even when applied to shafts as small as 0.040 in. diameter.

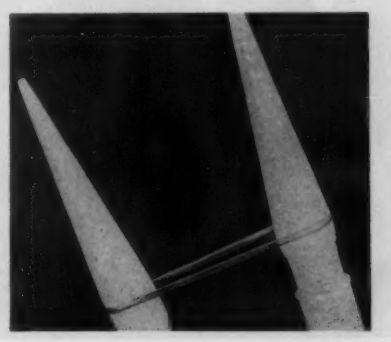
Splice free, the film belts are fabricated by stretching flat rings cut from sheet material. Placed over two cantilevered cones with cylindrical bases, the rings are driven by one cone (the other is free to rotate on a bearing assembly). Angle and distance between the cones are adjusted to permit a uniform advance to the cone base (and the required belt length). The process is then repeated until all edge wrinkles are stretched out of the belt.

A wedge-shaped cross section results from the fabrication technique, and this causes the belt to track off center on a crowned pulley center. To compensate for this characteristic, designers can crown the pulley, offsetting the radius center. As an alternative, rotational centerlines of the two pulleys can be skewed.

Tested extensively in the laboratory, the film belts have proved out well in Vanguard II, Tiros I, and Atlas-Score systems. Present plans call for their use in many future NASA meteorological satellites.



**Fabricated** from flat rings of sheet material, the belts are stretched and formed on revolving cones. When finished, their cross sections are wedge shaped. Although this form causes the belt to track off center, designers can easily compensate for the characteristic, NASA reports.

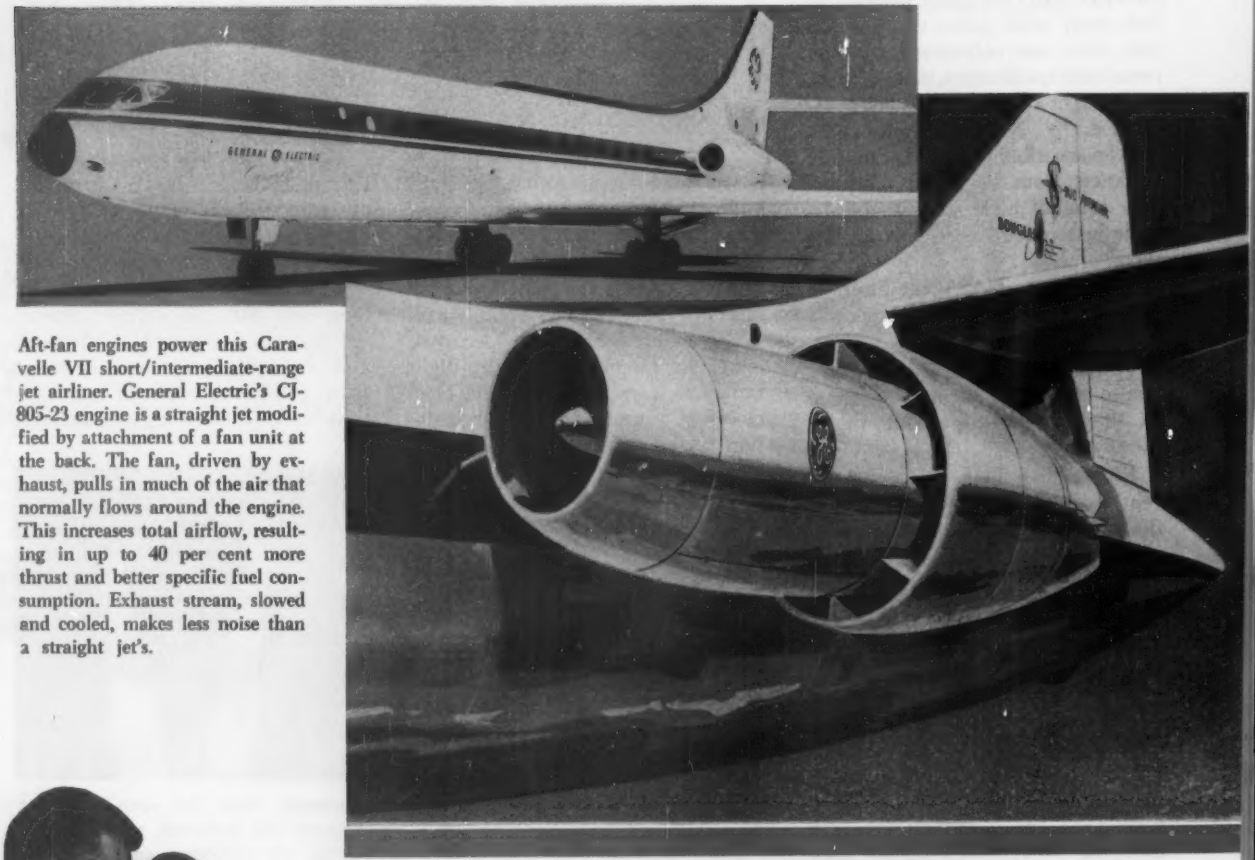


**Thin-film belts will be the subject of a full-length article soon to appear in MACHINE DESIGN. More information on performance and characteristics will be presented, and design criteria will be discussed.**

## ENGINEERING NEWS / PICTURE REPORT



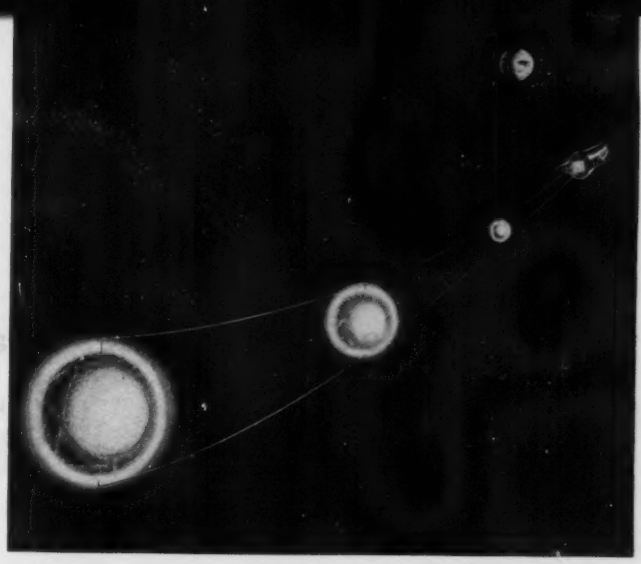
New appliance for cooking will be the telephone if a system developed by Westinghouse goes beyond the experimental stage. Relays, activated by a distant homemaker dialing her own telephone number, turn the stove or other electric appliance on or off, according to preset instructions.



Aft-fan engines power this Caravelle VII short/intermediate-range jet airliner. General Electric's CJ-805-23 engine is a straight jet modified by attachment of a fan unit at the back. The fan, driven by exhaust, pulls in much of the air that normally flows around the engine. This increases total airflow, resulting in up to 40 per cent more thrust and better specific fuel consumption. Exhaust stream, slowed and cooled, makes less noise than a straight jet's.



Metals and alloys with unique structures are being produced at California Institute of Technology. The method used, "splat cooling," involves shooting hot droplets of molten alloys against a refrigerated copper wheel which spins at high speed. Atoms of various metals, well-mixed in their molten state, cool so quickly (2,000,000 deg F per second) that they don't have a chance to realign into normal patterns. The most interesting changes in properties are expected to be electrical and magnetic, and the process may lead to synthesis of new superconductive alloys, according to its developer, Dr. Pol Duwez.



Powerplant in the rear, in the form of several 2-ft diam nuclear reactors, is proposed to take a space ship to Jupiter and supply its instruments with electricity for several years after the two-year trip. In an ion-beam propulsion system suggested by Dr. A. H. Olds of Lockheed's Missiles and Space Div., the small reactors would supply 1200-C heat to banks of thermionic generators for direct conversion into electrical energy. Dependable operation of this far-out system should result from absence of moving parts, according to Dr. Olds.




Straddling both a train and a truck roadway, the TransTainer can move a 25-ton piggyback unit in two minutes, loading or unloading as it travels. Individual electric motors and brakes control all motions. Easily maneuverable for use in storing, the TransTainer can stack containers two high. Builder is Pacific Coast Engineering Co.




Photocell the size of a paper match head automatically sets both shutter speed and lens opening on the new Polaroid model 900 camera. Before starting to shoot, the photographer merely turns a dial on the shutter housing to indicate speed of the film being used. The electric eye works with all films existing or contemplated for the Land camera, including color.

**The Iguana clings to a design**
**120,000,000 years old**





# For modern-appearing machinery design for welded steel

THE Iguana looks almost the same as its ancestors of the Mesozoic era one hundred twenty million years ago.

That may be fine for lizards whose needs have changed little. But it surely is no answer for the manufacturer who wants to survive in a competitive age.

Outmoded production methods can keep a company's products looking like fossils from ages gone by. While streamlined machines—lightweight, rigid, and easily modified to meet the quick-changing needs of modern times—are the result of properly designed fabrication with welded steel.

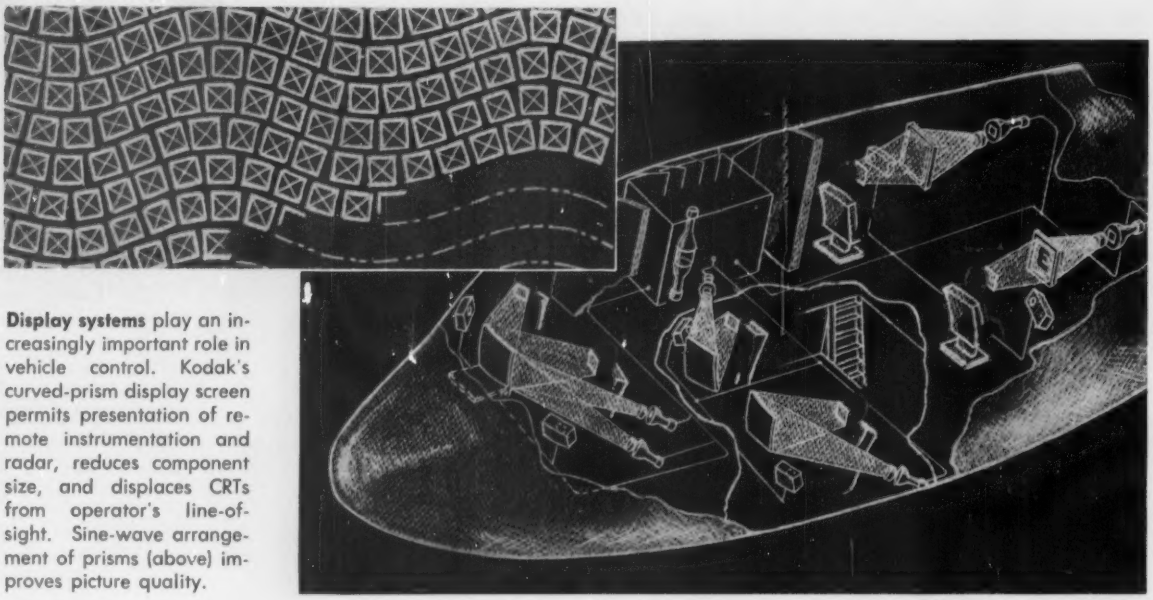
If you feel there are some areas of your company's manufacturing where you could gain a competitive advantage by switching to fabricated steel, call in your local LINCOLN Field Engineer. He won't design your product for you, but he can supply helpful time and cost-saving ideas when you are starting to change over.

**THE LINCOLN ELECTRIC COMPANY**
**Dept. 2030 • Cleveland 17, Ohio**

**LINCOLN WELDERS**



*Circle 415 on Page 19*



**Display systems** play an increasingly important role in vehicle control. Kodak's curved-prism display screen permits presentation of remote instrumentation and radar, reduces component size, and displaces CRTs from operator's line-of-sight. Sine-wave arrangement of prisms (above) improves picture quality.

Surfaced with thousands of tiny prisms, a new projection screen promises

# Ultrabright Data Displays

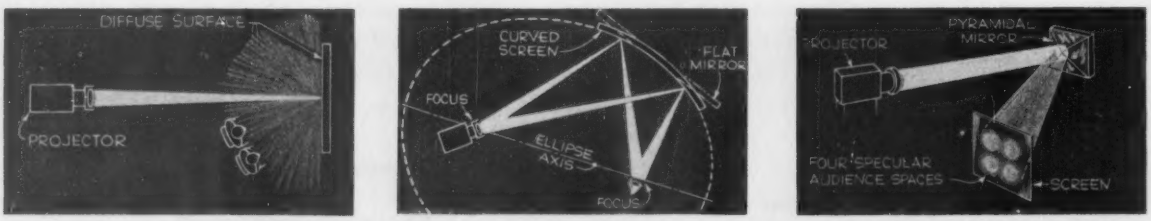
LOS ANGELES—Brightness of a projection screen gains several hundred times when surfaced with a recently developed material that can direct source-light to a selected audience.

The material is a film base embossed with a million lenses, or prisms, per sq in., coated with a highly reflective aluminized layer. The type of optical element—prism—used in the surface, can be chosen to give as broad or as narrow an "audience space" as desired. The narrower the audience space (that area from which the picture is visible), the brighter the image.

Limiting the audience space, as well as providing a bright image, permits several images to be projected on a single screen simultaneously for viewing by different audiences. No image interference occurs. This same property lends the additional advantage that extraneous light does not wash out projected images. The new screen is also a transmission element.

The developer, Eastman Kodak Apparatus and Optical Div., Rochester, N. Y., envisages its semispecular screen—aided by Fresnel lenses—being used in conjunction with small cathode ray tubes. The company points out that television screens are limited to about 30 in. diam, but that small (2.5-3.0 in. diam) CRTs can be used with a semispecular screen of almost unlimited size to produce a bright image. And many CRTs could project different data on one screen, for viewing from different locations.

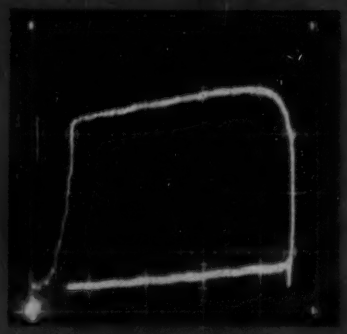
## Evolution of the Semispecular Screen . . .



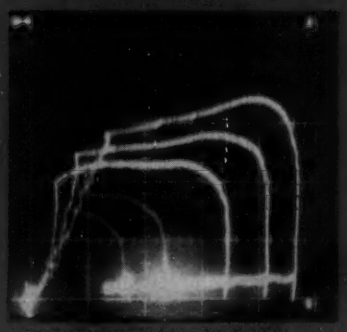

**Perfectly diffuse** flat screen (left) reflects light equally over a hemisphere. Scene is visible anywhere, but brightness is only a fraction of that of the projector. Most efficient screen—a mirror—reflects most of the light. But if flat mirror is used, scene is visible from only one point in the audience space, and appears only as one point on the screen. Elliptically curved mirror (center) reflects scene from the whole screen, but requires projector and viewer to be placed at foci of the ellipse. Many flat mirrors (right), arranged into prisms, provide overlapping multiple viewing points, which form a total scene. Millions of these tiny prisms, cast on a curved surface, form Kodak's semispecular screen.

*For the* **FIRST** *time!*

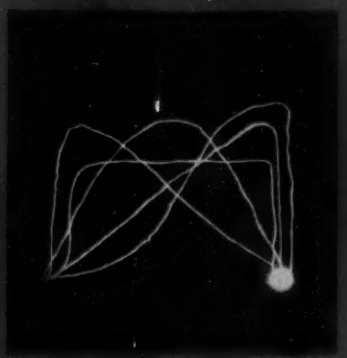
# STANDARD
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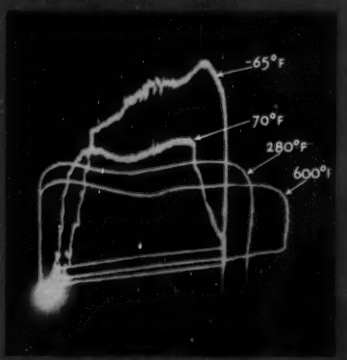
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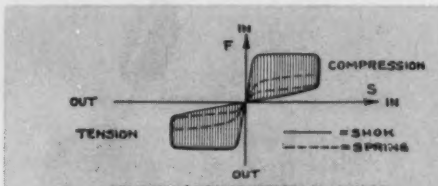
Circle 476 on Page 19

**SAVE Design Time by Specifying Spring and/or Shoks for Your Exact Energy Requirements FROM STANDARD COMPONENTS at Low Cost... Off-the-Shelf Delivery... Graphs Show Capabilities of units from the Standard Line.**

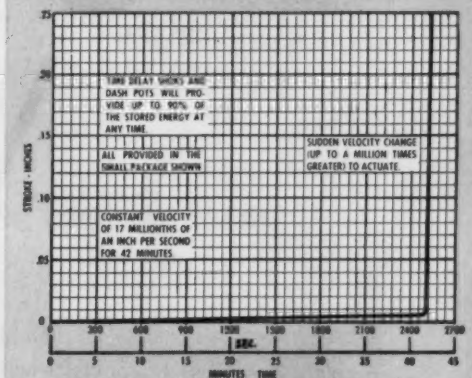
▶ Taylor Spring Shoks provide:— infinitely variable spring and/or dash pot energy capabilities from 50 to 250,000,000 inch pounds; controllable velocities from milliseconds to days; tension, compression, or both; fractional weight and space in direct acting, self-contained units; and original performance even after long storage. Accepted and used in military applications.




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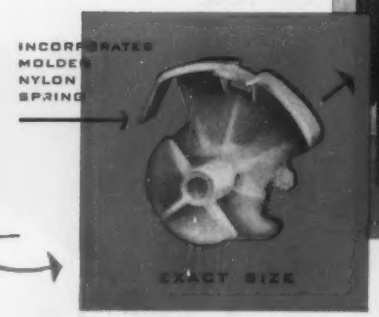

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Automatic Voting Machine Division
JAMESTOWN, NEW YORK




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## Portable Reactors Pass Round of Tests

WASHINGTON — Mobile nuclear power has come one step closer to reality, reports the Atomic Energy Commission. Both 300-w and 300-kw "portable" powerplants have been successfully operated recently.

### SNAP 10

The nuclear core designed for the SNAP-10 system is now in use. While not yet generating electricity, the core is making it possible for scientists to gather physics data that will be necessary for final design of the complete reactor system.

Developed and constructed for the AEC by Atomics International, division of North American Aviation Inc., the core measure 7 in. diam by 7 in. high, weighs less than 200 lb, and occupies about 1/5 cu ft. Divided into two identical units, it is "made critical" by bringing the halves together by remote control. In the completed SNAP-10 system, electricity will be generated by a thermocouple network from heat produced by the chain reaction. Electrical output of about 300 w is expected when the system is completed early next year.

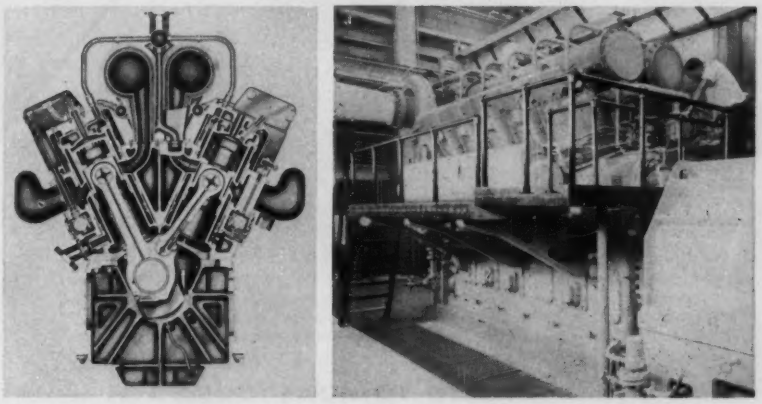
### Gas-Cooled Reactor

Development of a mobile nuclear powerplant for the Army passed a major test recently when the AEC's experimental gas-cooled reactor was "turned up" to full power. Critical since earlier this year, the reactor had been held back to a fraction of its power output capabilities.

In the new full-power experiment, the reactor was operated 48 hr at 1850 thermal kilowatts, then shut down as scheduled. Because the device is highly experimental, no system for producing electricity has been added. Energy produced is dissipated in a water cooling tower.

Designed for the first U. S. direct, closed-cycle nuclear plant, the reactor will heat a gas to drive a turbine. The system has been in the development phase for the past five years. Research conducted by Aerojet-General Corp. is now expected to make possible an operational prototype next year. The prototype will be transportable in four packages having a total weight of less than 38 tons.

## Two-Cycle V-10 Burns Natural Gas



**Teamed with a centrifugal compressor,** a new 4000-bhp natural-gas engine is now pumping gas on a Tennessee pipeline. Developed by Clark Bros. Co., Olean, N. Y., the two-cycle variable-speed (250—360 rpm) prime mover operates with 40 per cent thermal efficiency. The engine, designed for unattended operation is first in a new Clark series that will include V-12 and 14 models (4800 and 6400 bhp). It's also the first two-cycle engine ever to drive a centrifugal compressor on a pipeline, and the compressor is the first built by Clark to be driven by anything other than gas turbines or electric motors.

## Computers Share Memories Over the Phone



**Exchanging information directly** over the phone, two computers can have direct access to each other's memories for use in their own calculations. Introducing its 1009 data transmission unit recently, International Business Machines Corp., White Plains, N. Y., noted that the machine links the magnetic core memories of two solid-state IBM 1401 or 7701 computers over telephone and telegraph lines, utilizing each computer as a data-transmission terminal. Transmit and receive programs, controlled by the computers, are loaded at both ends to relay 150 characters a second from core to core through modulating and demodulating subsets attached to the telephone circuit.

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Even so, there is a big difference between providing nondestructive testing *equipment* and providing solutions to testing problems.

Providing *solutions* is the full time job of the entire Field Engineering group. They are closely supported by over 80 Magnaflux design and project engineers, full Research staff and technical men whose whole job is to develop, test and improve the equipment and the materials to make nondestructive testing most useful and profitable for you.

In addition we offer nation-wide Commercial Inspection Service through Magnaflux Corporation owned test centers in fifteen principal cities. These plants provide testing to meet military and individual specifications, one part or one million, on regular schedules or to meet emergencies. Also complete Field Inspection Service any place, any time.

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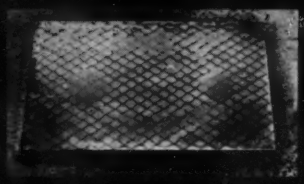
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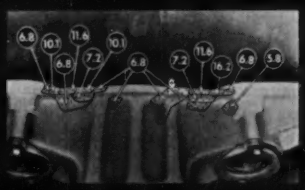
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# Newest Propeller Shortens Runways, Extends Flight Ranges

## *Hamilton Standard's adjustable-camber prop climaxes 40-year search*




**Aerodynamically equivalent** to a single deeply cambered airfoil, staggered blades in Hamilton Standard's new propeller meet at an angle (trailing edge to leading edge) to generate high thrust in takeoff and climb. In cruising flight, pitches of blades forming each pair change differentially and the composite "blade" flattens for low-drag, high-efficiency operation.

WINDSOR LOCKS, CONN.—A pioneer in propeller design, Hamilton Standard Division (United Aircraft Corp.), has announced the successful conclusion of a 40-year design search—an adjustable-camber propeller. For high-speed transports, it promises flight ranges up to 30 per cent longer; for low-level attack planes, flight speeds will be advanced by 50 knots. Short-field performances and load-carry capacities will be improved across the board.

On a lift vs. drag basis, the propeller has long represented a design compromise. Like the aircraft wing, propeller blades should generate high lift (thrust) during takeoff and climb. Long-range cruising, in contrast, demands low-lift, low-drag airfoil configurations. Until the new Hamilton standard development, propulsion specialists have bridged (at least partially) such conflicting requirements by designing propellers with pitch-changing mechanisms—in two-position, controllable-pitch, and constant-speed forms.

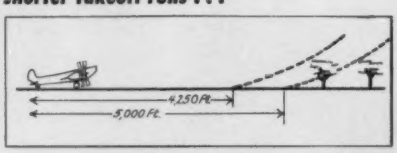
But the search for the ideal solution—a means for adjusting blade-surface curvature (camber)—has until now been a failure. Lightweight mechanisms (like those that adjust wing camber by extending and retracting flaps for efficient takeoff and cruise) either malfunctioned or failed under the high centrifugal loads imposed by propeller rotation. Inflatable cuffs were no more successful.

Trying a new tack, Hamilton Standard engineers staggered pairs of blades, one behind the other, on a common hub. Pitch of each blade can be independently set and, in effect, each blade pair creates a single airfoil with an adjustable camber.

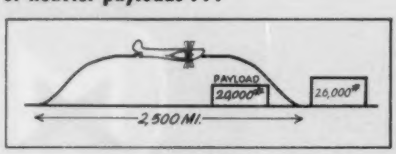
In operation, the forward blade assumes a relatively low angle for takeoff and climb. The rear blade—which is set at a higher angle—combines with the front blade to give the effect of a high-camber, high-lift airfoil. During cruise, blades in each pair flatten out into near alignment, giving a low curvature, low-drag airfoil configuration.

Having proved out in extensive wind-tunnel tests at United Aircraft's Research Laboratories, the propeller will be refined and further developed under a Navy contract. A full-scale prototype is scheduled for tunnel and flight test in about nine months.

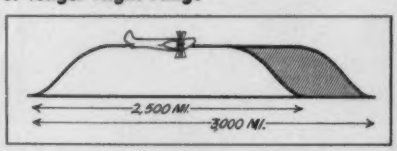
***From a new prop, shorter takeoff runs . . .***




***or heavier payloads . . .***




***or longer flight range***






Circle 419 on Page 19→

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‡ Pat. Pending.

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*In Canada, write Canadian General Electric, Peterborough, Ontario.*

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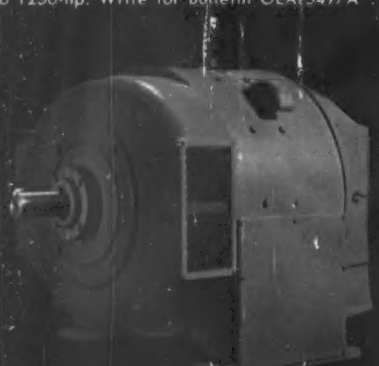
## HEAVY DUTY M-G SETS

Reliable power conversion for main, auxiliary and process line drives



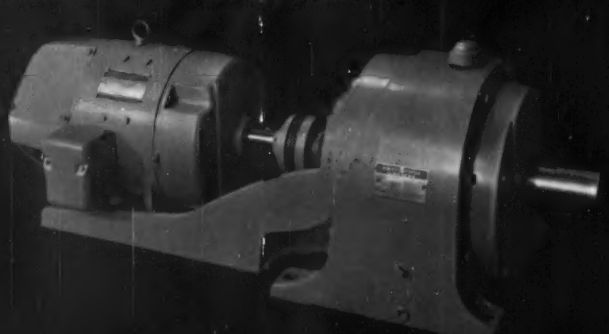
## CD-1000 D-C MOTORS

Performance proved. Quality designed. 250 to 1250-hp. Write for Bulletin GEA-5497A*.



## ALL-MOTOR GEAR-MOTOR

A-c or d-c. 1 to 75-hp. Simplified maintenance. Produced by Gear Motor & Transmission Components Dept. Write for Bulletin GEA-6704*.





**Balanced and weighted** model of the Courier goes through shake tests. Vibrations imposed are similar to those expected when the Thor-Able-Star propulsion system accelerates the satellite into orbit. Two lightweight hemispheres make up the shell. The hemispheres were formed from a plastic honeycomb sandwiched between skins of fiberglass epoxy. Allowable shear stress, in excess of 4000 psi, is more than adequate to support solar-cell arrays and electronic components.

*Coming: Courier,*

# Fastest Talker in Space

DESIGNED as space-based runners for earthbound message centers, Courier satellites will soon link all parts of the Free World in a reliable microwave-communications network. Equipped to transmit and record information at incredible speeds, the satellites will converse with ground stations they pass over.

Primary mission of the first orbiting Courier (last month's launch was unsuccessful) will be to connect two widely separated Army message stations having twenty continuously available 100-wpm teletype channels. Circling the globe 14 times per day, the satellite will be in sight of each ground station for at least ten 5-min periods. During these periods, it will simultaneously send and accept 68,000 wpm exchanging up to 3.4 million words per day with each station (equal to 564 pages of words in a standard newspaper).

### *Two of Everything*

Fresh out of the Philco Western Development Laboratories, Palo Alto, Calif., the first Courier boasts high reliability, and later models will do even better—they're expected to achieve a 90 per cent probability of remaining operational for one year. To obtain this performance, Philco engineers designed in duplicate: They alloted nearly half the allowable weight and space to spare equipment. If a component fails, its replacement can be switched in by ground command.

Precise ground control is made possible by a built-in logic system

### Profile of the Courier

**Satellite**
Weight—500 lb
Size—51 in. diam
Spin Rate— 40 rpm
Speed—14,400 mph
Altitude—680 miles

**Power Supply**
Primary—28-v, 12 amp-hr Nickel-Cadmium Batteries
Charging—19,152 Solar Cells
Charging Rate—1.8 amp

**Power Consumption**
Stand by—10 w
Active—225 w

**Data Storage**
Method—5 tape recorders
Capacity—68,000 wpm
Read-in, Read-Out Time—5 min

←Circle 419 on Page 19

that checks all incoming signals for procedural correctness, signal-strength adequacy, and compatibility. After approving the inputs, the system routes them to the appropriate apparatus, then sends an acknowledgment back to the ground.

To pinpoint troubles, 35 separate parameters are telemetered from within the satellite, including information on battery voltages, currents, internal and external temperatures, recorder tape positions, and input and output signal strengths. The ground station receives this data continuously and records it on both magnetic tape and visual recorders. In addition, critical satellite conditions may be displayed on visual indicators for quick-look information. When between stations, the satellite sends out a beacon signal. When a ground station picks it up, the satellite is commanded to switch from "standby" to "active" operation and the beacon switches off. If the ground signal fades or is lost, the beacon again turns on, informing ground personnel that something is amiss.

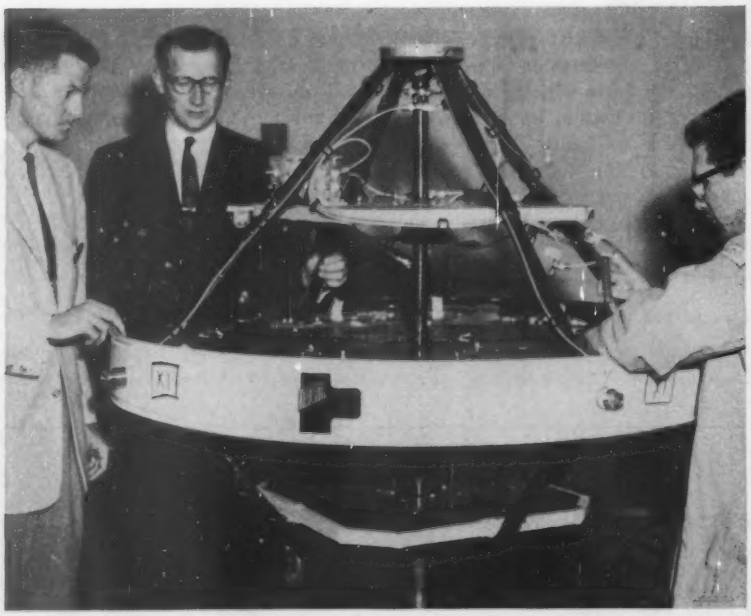
### Covered with Solar Cells

A self-sufficient space-age messenger, Courier has a built-in power source consisting of about 20,000 solar cells. Arranged on the sphere (they cover about 70 per cent of its area), the cells convert sunlight to about 70 watts of power, operating with an efficiency of approximately 8.5 per cent. Groups of 84 solar cells are series-connected in 14 x 6 matrices.

Power is stored in a two-pack nickel-cadmium battery designed for a minimum of 10,000 charge-discharge cycles. Failure of one battery pack will not cause failure of the system.

### First of a Family

Courier I is part of a program designed to demonstrate the feasibility of active repeater satellites for global communication networks. Because it can handle more traffic than the two ground stations can provide, Courier will work alone for the time being. In the future, when more stations are broadcasting, the satellite may "see" two or more at the same time, and its tape recorders may become saturated. In this case, more satellites will probably be needed. A second advantage of more satellites is, of course, speed up in communications: Ground stations will be able to transmit more often and satellites may even "talk among themselves."



**Communication components** will be mounted on internal platforms in the Courier. Frame, made from welded aluminum tubing, supports three honeycomb-sandwich shelves and fastens to the equatorial band of the shell at four points.






# How safe are Fire-Resistant Fluids

## *INSIDE your pumps?*

Depends on whether your fluids are *fortified* to provide more than just fire-safety. The pump parts above were subjected to the most rigorous pump tests yet conducted on Houghto-Safe fluids by the Houghton Research Laboratories. Results prove conclusively that Houghto-Safe fluids offer a unique combination of fire resistance and lubricity. Pump wear in every test was extremely low—comparable in many applications to that with premium oils.

Houghto-Safe fluids are *fortified* to give you much more than fire-safety. Lubricity; oxidation stability, and rust preventive characteristics are built-right-in to make Houghto-Safe the finest fire-resistant hydraulic medium you can buy. And when you buy from Houghton you get *complete* hydraulic service from the only manufacturer who offers all types of fluids (Water-Glycol, Phosphate-Ester and Emulsion Types) *plus* compatible packings for any industrial hydraulic system.

**FREE!** 48-page Handbook of authoritative and helpful information on selection and application of fire-resistant hydraulic fluids and compatible packings. Write E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa.



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saves 35 MACHINING OPERATIONS with INVESTMENT CASTING

This barrel of a .22 caliber target revolver is now being cast by Hitchiner's new ceramic shell process. This new investment casting technique provides sufficient close tolerances and finishes to eliminate the need for 35 machining operations. Gun barrel tolerance of 0.006 inch was normal, but plus over minus 0.001 inch was maintained on certain areas. Only external finishing needed was partial polishing.

These savings have allowed the manufacturer of this revolver to sell it for considerably less than a similar previous model.

Through investment casting, parts can be designed for function and maximum operating efficiency with the widest selection of alloys from which to choose. This freedom from manufacturing problems can result in more flexibility in design and less waste in production.

Send us a sample or blueprint and check your specific problem with our "engineered quotation" — no obligation, of course.



*Find out how our new ceramic shell technique can possibly benefit you. Send for our free, new revised brochure explaining investment castings.*

**HITCHINER**
MANUFACTURING COMPANY INC.
MILFORD 37, NEW HAMPSHIRE

Coast to Coast Engineering Representatives

Circle 421 on Page 19



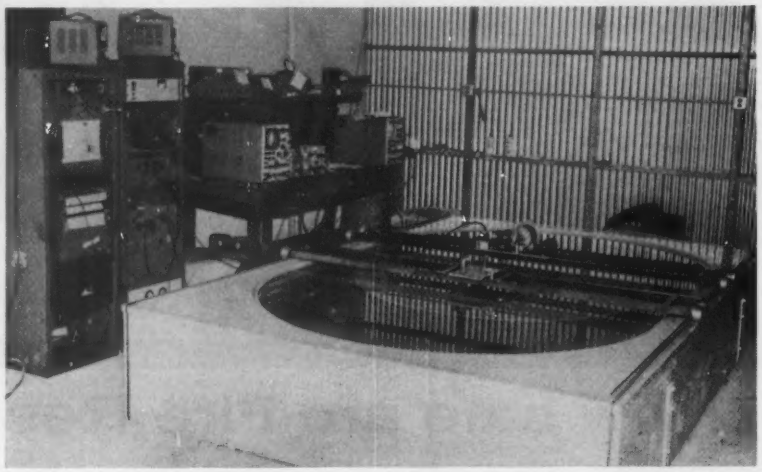
# Silent Service Gets an Echo-Free Pool

## Stray "Pings" Controlled by an Elliptical Bottom

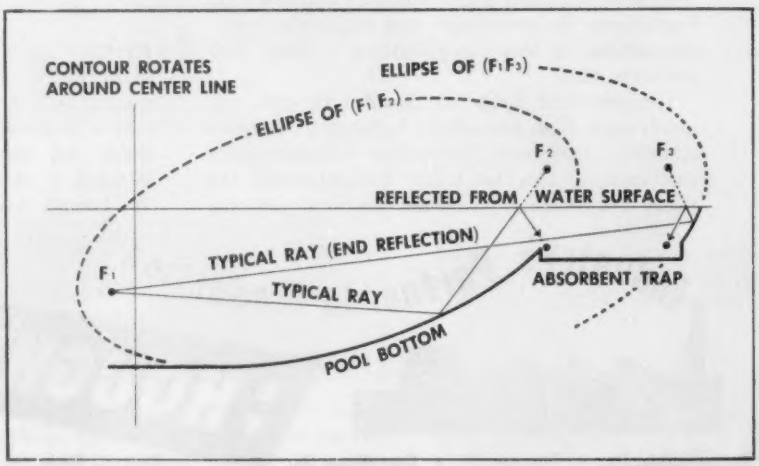
SAN DIEGO—Construction of a huge sonar calibration pool—300 ft long, 200 ft wide, and 40 ft deep—is being planned by the Navy to check out vital hardware designed for antisubmarine warfare. The tank, designed with a contoured bottom, will be echo-free and far more efficient for controlled transducer testing than the shallow natural lake now being used by scientists at the Navy Electronics Lab., San Diego, Calif.

Transducers, vital to sonar systems, are a critical component in the over-all antisubmarine warfare program. And as submarines spend an increasing percentage of their life completely submerged, they depend more and more on transducers as navigational aids.

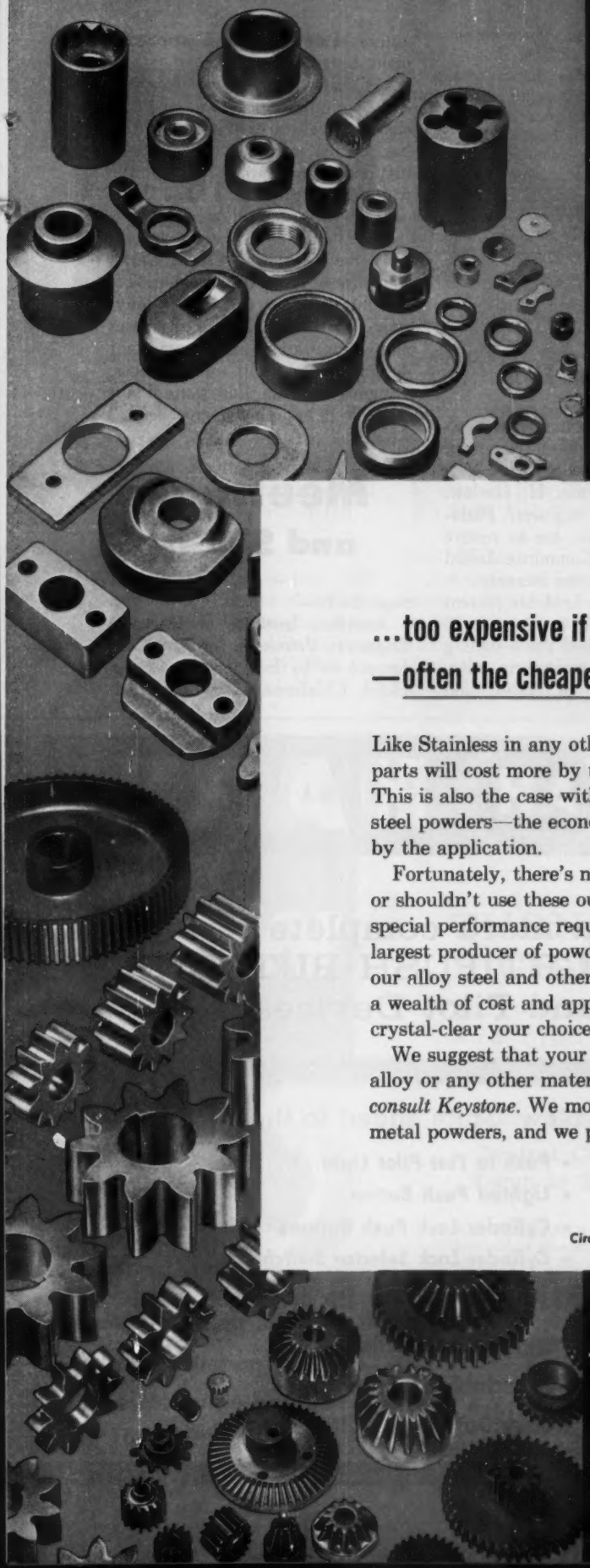
NEL's calibration tank will be an effective tool in exploring new applications of transducers and electronics in general in ASW and oceanographic studies.



**Anechoic pool of water** (1/30 scale model, above) will have a contoured bottom in the shape of an ellipse of revolution (below). Surface of the ellipse sweeps a central bowl which will be 160 ft in diameter. Test transducer is located at the focus of one of the ellipse points, which causes all sound reflection to be projected to (or behind) the other focus. This eliminates echos which usually hamper testing effectiveness. Area behind the central bowl, arranged as a sound trap, absorbs any vibrations which might stray from the focal point. Trap is axially aligned with the transducers to accommodate the higher sound pressures provided by transducer directivity.



FACTS ON **KEYSTONE** POWDER METALLURGY



## Powder Metal Parts of STAINLESS and ALLOY STEELS

### ...too expensive if you don't need 'em —often the cheapest, if you do!

Like Stainless in any other form, your powdered stainless parts will cost more by the pound and do more by the piece. This is also the case with parts of high-strength alloy steel powders—the economies are properly determined solely by the application.

Fortunately, there's no mystery about whether you should or shouldn't use these outstanding materials for your special performance requirements. Our experience as the largest producer of powdered stainless parts is as intensive as our alloy steel and other metals background is broad. We have a wealth of cost and application data that will make crystal-clear your choice and the alternatives to consider.

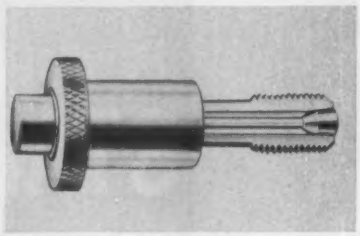
We suggest that your first step in deciding on stainless, alloy or any other material for your projected part is to *consult Keystone*. We mold and sinter all the commercial metal powders, and we play no favorites!

Circle 422 on Page 19

Keystone
CARBON COMPANY
St. Marys, Pa.
POWDERED METAL PARTS DIVISION

## Quick Disconnect Spreads Threads in New Fastener

**Speedy assembly and disassembly** can be achieved with a patented fastener that combines the advantages of threads with those of a quick-disconnect device. Bolt and nut threads are disengaged by depressing a button that operates a spring-loaded mandrel. Avdel Inc., Burbank, Calif., claims the mandrel maintains positive, locked-in contact between threads.



## ASME Honors Three in Power-Generation Field

NEW YORK—Three engineers have won awards for their achievements in the field of power generation from the American Society of Mechanical Engineers.

Mr. Ernest C. Gaston, president, Executive Div., Southern Services Inc., Birmingham, Ala., will receive the George Westinghouse gold medal for "distinguished leadership in generating-station design and operation in the development of a major power system."

Mr. Sigmund N. Fiala, vice president and chief engineer, American Gas and Electric Service Corp., New York, and Mr. James H. Harlow, chief mechanical engineer, Philadelphia Electric Co., are to receive the Prime Movers Committee Award for contributions to the literature.

Mr. Gaston has held his present position since 1957. In the last 20 years, he has directed the designing of 44 new steam generating units. He is a member of ASME and author of several articles on power-plant design.

Mr. Fiala, who has held his present post since 1954, was recently elected a Fellow of ASME. He also has written many articles concerning power generation. His award-winning contribution is "The Critical and Two-Phase Flow of Steam."

Mr. Harlow, a Fellow of ASME, has served on many of the society's committees. His most recent project at Phila. Electric Co. is the Eddystone Station, which incorporates many innovations in steam-plant design. His award is for the paper, "Engineering the Eddystone Plant for 5000 lb and 1200 degree steam."

## Meetings and Shows

Sept. 25-28—

**American Institute of Electrical Engineers.** Petroleum Industry Conference to be held at the Skirvin Hotel, Oklahoma City, Okla. Ad-

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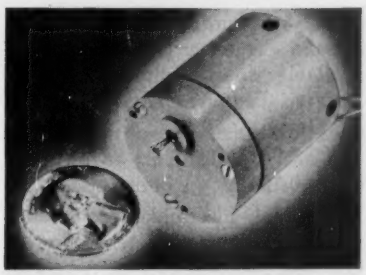
**Plus an A-H Exclusive** →

**Rugged Construction**

**Dependable Operation**

**Heavy Duty Push Button Ratings**

### Sun Powers Rugged Motor



**Running on a solar battery,** a small dc motor needs as little as 1/3 volt, to overcome starting resistance. Its armature consists only of copper wire rotating in a permanent magnet field. Giannini Controls Corp., Duarte, Calif., claims the milliwatt motor can withstand a 50-g shock, and 20-g random vibration; will function in temperatures from −55 to 80 C. To reduce friction, 5:1 gear reduction is made an integral part of the armature and cone-type ball-bearings are used.

ditional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

**Sept. 26-28—**

**Standards Engineers Society.** Ninth Annual Meeting to be held at the Hilton Hotel, Pittsburgh.

**Sept. 26-29—**

**American Welding Society.** Fall Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Additional information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

**Sept. 26-30—**

**Instrument Society of America.** Instrument-Automation Conference and Exhibit and 15th Annual Meeting to be held in the Coliseum, New York. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

**Sept. 27-30—**

**Association of Iron and Steel Engineers.** Exposition and Convention to be held at the Auditorium Hotel, Cleveland. Further information is available form AISE, 1010 Empire Bldg., Pittsburgh 22, Pa.

**Sept. 27-30—**

**American Rocket Society Inc.** Space Power Systems Conference to be held at the Miramar Hotel, Santa Monica, Calif. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

**Oct. 9-12—**

**American Society of Mechanical Engineers.** Rubber and Plastics Conference to be held at the Lawrence Hotel, Erie, Pa. Further information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

**Oct. 9-14—**

**American Institute of Electrical Engineers.** Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

**Oct. 10-11—**

**Sixth Conference on Mechanisms** to be held at Purdue University, Lafayette, Ind. Conference is spon-


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Circle 423 on Page 19



# Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for **AD-66av.**

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**DUFF-NORTON JACKS**
Ratchet • Screw
Hydraulic • Worm Gear

DUFF-NORTON

**COFFING HOISTS**
Ratchet Lever • Air
Hand Chain • Electric




sored by Purdue and MACHINE DESIGN. Further information is available from Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Oct. 10-12—

**National Electronics Conference** to be held at the Hotel Sherman, Chicago. Sponsors include American Institute of Electrical Engineers, Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University, and University of Illinois. Further information can be obtained from NEC headquarters, 228 N. La Salle St., Chicago 1, Ill.

Oct. 10-14—

**Society of Automotive Engineers Inc.** National Aeronautic Meeting, including manufacturing forum and engineering display, to be held at the Ambassador Hotel, Los Angeles. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N.Y.

Oct. 12—

**Cast Bronze Bearing Institute.** Annual Meeting to be held at the Grove Park Inn, Asheville, N. C. Further information is available from the institute, 1604 Chicago Ave., Evanston, Ill.

Oct. 12-14—

**American Vacuum Society.** Seventh National Symposium to be held at the Cleveland-Sheraton Hotel, Cleveland. Further information is available from society headquarters, P. O. Box 1282, Boston 9, Mass.

Oct. 12-14—

**Gray Iron Founders' Society** 32nd Annual Meeting to be held at the Netherland Hilton Hotel, Cincinnati. Further information is available from society headquarters, National City-E. Sixth Bldg., Cleveland 13, Ohio.

Oct. 13-15—

**Non-Ferrous Founders' Society.** Annual Meeting to be held at the Grove Park Inn, Asheville, N. C. Further information can be obtained from society headquarters, 1604 Chicago Ave., Evanston, Ill.

**Oct. 14-15—**

**American Society for Quality Control.** 15th Midwest Conference to be held at the Broadview Hotel, Wichita, Kans. Further information can be obtained from the program and publicity vice-chairman, Howard K. Mitchell, 602 S. Brookside, Wichita 18, Kans.

**Oct. 16-22—**

**Society of Motion Picture and Television Engineers.** Fifth International Congress on High-Speed Photography to be at the Sheraton-Park Hotel, Washington, D. C. Additional information is available from Max Beard, Chief of Photographic Div., U. S. Naval Ordnance Laboratory, Silver Spring, Md.

**Oct. 17-19—**

**The Magnesium Association.** Annual Convention to be held at the Pick-Carter Hotel, Cleveland. Additional information can be obtained from association headquarters, 122 E. 42nd St., New York 17, N. Y.

**Oct. 17-19—**

**American Society of Mechanical Engineers — American Society of Lubricating Engineers.** Lubrication Conference to be held at the Statler Hilton Hotel, Boston. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

**Oct. 17-21—**

**American Society for Metals.** 42nd National Metal Congress and




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Circle 425 on Page 19

Exposition to be held at the Trade and Convention Center and the Bellevue-Stratford Hotel, Philadelphia. Further information can be obtained from ASM headquarters, Metals Park, Novelty, Ohio.

Oct. 18-21—

**National Society of Professional Engineers.** Fall Meeting to be held at the Hilton Hotel, Denver. Additional information is available from society headquarters, 2029 K St. N. W., Washington 6, D. C.

Oct. 19-21—

**Society for Experimental Stress Analysis.** Annual Meeting to be held at the Hotel Claremont, Berkeley, Calif. Further information can be obtained from SESA headquarters, P. O. Box 168, Cambridge 39, Mass.

Oct. 24-25—

**American Society of Mechanical Engineers-American Institute of Mining, Metallurgical and Petroleum Engineers.** Fuels Conference to be held at the Daniel Boone Hotel, Charleston, W. Va. Further information can be obtained from ASME, 29 W. 39th St., New York 18, N. Y.

Oct. 25-27—

**Society of Automotive Engineers Inc.** National Transportation Meeting to be held at the Hotel Leamington, Minneapolis. Additional information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 27-39—

**Aircraft Electrical Society.** Industry Display to be held at the Pan Pacific Auditorium, Los Angeles. Additional information is available from society headquarters, 3540 Wilshire Blvd., Los Angeles, Calif.

## Short Courses and Symposia

Oct. 3, 4, 5—

**Three seminars on drafting,** "How To Get More for Your Drafting Dollar," to be held at the Pick-Carter Hotel, Cleveland. Additional information can be obtained from the


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CHICAGO—Dodge-Chicago Industrial Equipment Co., 330 E. 24th St.
Patlyn Gears and Transmissions Corp., 2456 W. 38th St.
Samuel Harris and Co., 114 N. Clinton St.

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NEWARK—Dodge-Newark Supply Co., Inc., 20 Mt. Pleasant Ave.
Newark Pulley Co. Inc., 215 Frelinghuysen Ave.
NEW BRUNSWICK—Slingman Industrial Supply Co., 143 Neilson St.

**NEW YORK**
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BUFFALO—Industrial Transmissions, Inc., 190 Main St.
Root, Neal and Co., 64 Peabody St.
LONG ISLAND CITY—Beardslee Transmission Equipment Co., 27-22 Jackson Ave.
NEW YORK CITY—General Chain and Belt Co., 292 Lafayette St.
Patron Transmission Co., 129 Grand St.
RICHMOND HILL—Dale Gear and Bearing Supply Co., 114-15 Atlantic Ave.
ROCHESTER—John M. Forster Co., 110 Mill St.
SYRACUSE—Syracuse Supply Co., P. O. Box 1044

**NORTH CAROLINA**
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**OHIO**
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CINCINNATI—Cincinnati Transmission Co., 2206 Langdon Farm Rd.
Wirthlin-Mann Co., 1930 Dana Ave.
CLEVELAND—Bearing Distributors, Inc., 2618 Carnegie Ave.
Meier Transmission, Inc., 4415 Perkins Ave.
COLUMBUS—Ohio Transmission Co., 666 Parsons Ave.
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TOLEDO—Ohio Belting and Transmission Co., 300 N. Westwood Ave.
Reliable Belting and Transmission Co., 1515 Cherry St.

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Industrial Transmission Machinery, Inc., 209 N. Third St.
PITTSBURGH—Standard-Machinists Supply Co., S. Second and McKean Sts.
Transmission Equipment Co., 1200 Muriel St.

**RHODE ISLAND**
PROVIDENCE—Machine Parts Corp., 271 Washington St.

**TEXAS**
DALLAS—Cottingham Bearings and Service, Inc., 401 Exposition St.
FORT WORTH—Welsco Co., 1108-10 Norwood St.
HOUSTON—Isaacson Chain and Belting Co., 1200 Jackson St.

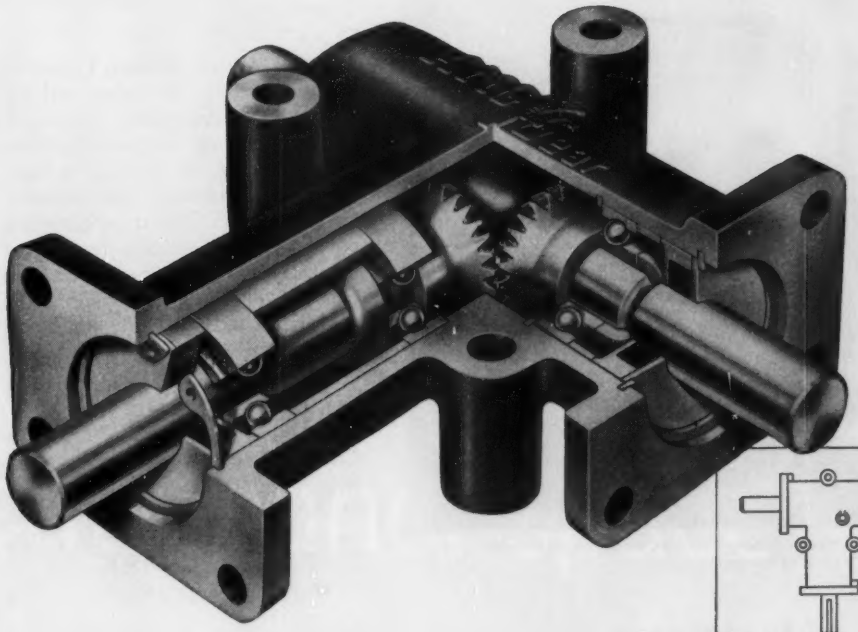
**WASHINGTON**
SEATTLE—Cragin and Co., 932 First Ave., S.

**WISCONSIN**
MILWAUKEE—Badger Bearing Co., 1125 N. Van Buren St.
Wisconsin Bearing Co., 1310 S. 43rd St.

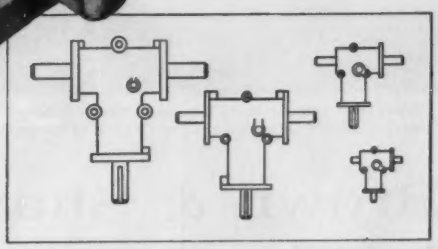
**IN CANADA**
TORONTO—Winnett Boyd, Ltd., 745 Mt. Pleasant Rd.

AIRBORNE®
*Engineered Equipment for Aircraft and Industry*
**AIRBORNE ACCESSORIES CORPORATION**
HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

# There is only one ANGLgear*... and it is made only by Airborne



Quality of ANGLgear construction is evident in cutaway view. ANGLgear gives you all the features of other drives, plus greater hp range (⅓ to 5); permanent lubrication; and Coniflex* design gears for more even load distribution, reduced wear, quieter operation.



ANGLgear is available from local distributor stocks in 4 sizes, 16 models, with various gearing and shaft options.

ANGLgear – introduced in 1951– is the *original* standardized right-angle drive. It is also the No. 1 product in its field – in sales, availability, quality, performance. Witness the thousands of satisfied customers who have bought ANGLgear to date – for applications ranging from simple manual control of valves to classified installations aboard nuclear submarines.

In design and construction, ANGLgear has been refined to the point of being virtually foolproof, provided it is not grossly overloaded. Take a unit off the shelf, install it, run it–for years. And attention is seldom required.

Besides being maintenance-free, ANGLgear is also easy to design into your power transmission systems because of its universal mounting feature. And it invariably costs less than other types of drives. ANGLgear is distributed nationally and is available immediately from local distributor stocks in the models listed here. Special sizes, special gear ratios, etc., can also be furnished. For complete engineering data, contact our local distributor, or write direct for new Catalog IA-58. *ANGLgear design template kits are available on request.*

*Trademark of the Gleason Works

**BASIC MODEL DATA**

| Model | Type | Gear Ratio | HP | RPM Output Shaft | Ultimate Static Torque lb. in. Output Shaft | Shaft Dia. | Wt., lb. |
|---|---|---|---|---|---|---|---|
| R-300 | 2-way | 1:1 | 1/3 | 1800 | 250 | 3/8 | .5 |
| R-300-2 | 2-way | 2:1 | 1/5 | 1800 | 250 | 3/8 | .5 |
| R-310 | 3-way | 1:1 | 1/3 | 1800 | 250 | 3/8 | .5 |
| R-310-2 | 3-way | 2:1 | 1/5 | 1800 | 250 | 3/8 | .5 |
| R-320 | 2-way | 1:1 | 1 | 1800 | 1000 | 5/8 | 2.2 |
| R-320-2 | 2-way | 2:1 | 3/5 | 1800 | 1000 | 5/8 | 2.2 |
| R-330 | 3-way | 1:1 | 1 | 1800 | 1000 | 5/8 | 2.4 |
| R-330-2 | 3-way | 2:1 | 3/5 | 1800 | 1000 | 5/8 | 2.4 |
| R-333 | 2-way | 1:1 | 2-1/4 | 1200 | 1500 | 3/4 | 8.7 |
| R-333-2 | 2-way | 2:1 | 2-1/4 | 1200 | 1500 | 3/4 | 8.7 |
| R-335 | 3-way | 1:1 | 2-1/4 | 1200 | 1500 | 3/4 | 9.0 |
| R-335-2 | 3-way | 2:1 | 2-1/4 | 1200 | 1500 | 3/4 | 9.0 |
| R-340 | 2-way | 1:1 | 5 | 1200 | 2500 | 1 | 14.5 |
| R-340-2 | 2-way | 2:1 | 5 | 1200 | 2500 | 1 | 14.5 |
| R-350 | 3-way | 1:1 | 5 | 1200 | 2500 | 1 | 15 |
| R-350-2 | 3-way | 2:1 | 5 | 1200 | 2500 | 1 | 15 |

AIRBORNE®

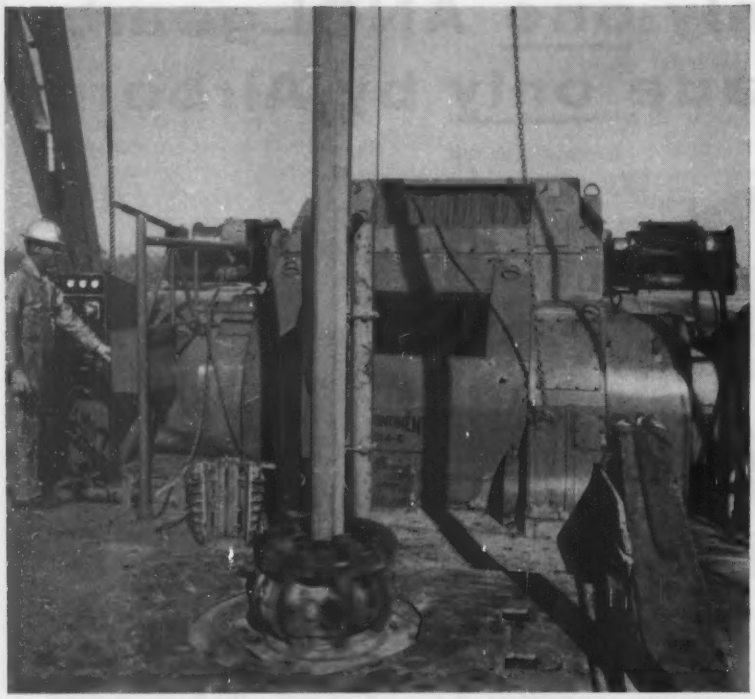
*Engineered Equipment for Aircraft and Industry*

**AIRBORNE ACCESSORIES CORPORATION**

HILLSIDE 5, NEW JERSEY



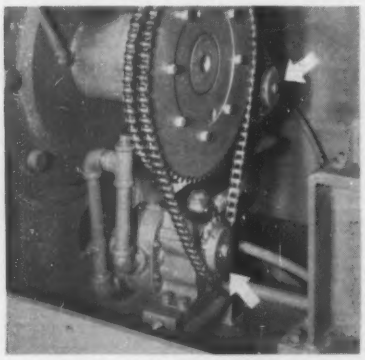
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Drawworks manufactured by Mid-Continent Supply Co., Fort Worth, provide rotating and hoisting action to drill oil wells more than 20,000 feet deep.

# Brown & Sharpe lubricating pumps help drilling rigs strike oil

There's a carefully-considered reason why designers at Mid-Continent Supply Co. — world's largest independent oil field supply company — use Brown & Sharpe pumps to lubricate their big "drawworks."



Two B&S No. 3S gear pumps (arrows) flood main chain drive (not shown) with oil. Either separately-driven pump will do the job alone.

They must take every precaution against breakdowns in these giants, rated up to 2000 input HP, that turn and hoist miles-long steel drill "strings."

B&S pumps were first tried by Mid-Continent several years ago — proved so dependable they've been used ever since.

In this customer's own words — "Brown & Sharpe pumps do the job we selected them for; have proved entirely satisfactory over a series of years". Quite a compliment, from this type of company, so highly experienced in pumps!

To help *your* machines "strike it rich" — contact Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, R. I. — or your nearest B&S engineer-representative.

**Brown & Sharpe**

PRECISION CENTER




seminars' sponsor, National Institute of Management Inc., 1419 National City Bank Bldg., Cleveland 14, Ohio.

Oct. 4-7—

**Eighth Annual Human Engineering Institute** to be conducted by Dunlap & Associates, Stamford, Conn. Program will include three days of technical sessions, a half-day on management and contractual aspects of human engineering efforts, and opportunity for private conferences. Further information can be obtained from Dunlap & Associates, 429 Atlantic St., Stamford, Conn.

Oct. 6-8—

**American Society for Quality Control Workshop-Seminar** to be held at the Statler Hilton Hotel, St. Louis. Further information can be obtained from Fourth ASQC Workshop-Seminar, ASQC, 161 W. Wisconsin Ave., Milwaukee 3, Wis.

Oct. 14-15—

**Symposium on recent advances in the technology of photographic rapid processing** to be held in Washington, D. C. Sponsor is the Society of Photographic Scientists & Engineers, and the symposium will be held in co-operation with the Fifth International Congress on High-Speed Photography. Further information is available from SPSE, Box 1609, Main Post Office, Washington, D. C.

Oct. 20-21—

**National Symposium on Hypervelocity Techniques,** sponsored by the Institute of the Aeronautical Sciences, to be held at the Shirley-Savoy Hotel, Denver. Additional information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Oct. 26-27—

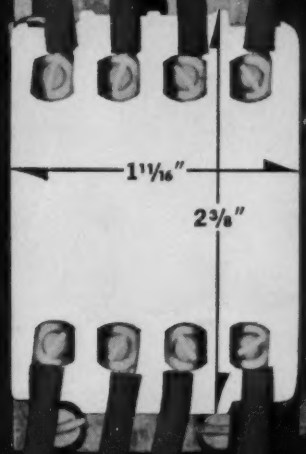
**Computer Applications Symposium,** sponsored by Armour Research Foundation, to be held at the Morrison Hotel, Chicago. Additional information is available from Andrew Ungar, Conference Program Chairman, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.



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# NEW MACHINE TOOL RELAY
# cuts panel space



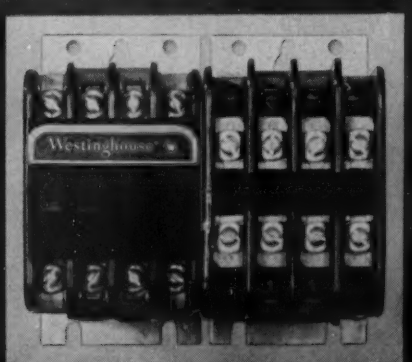

Actual size photo of machine tool panel

# new machine tool relay cuts panel space 50%, reduces installed cost over 20%




ACTUAL SIZE

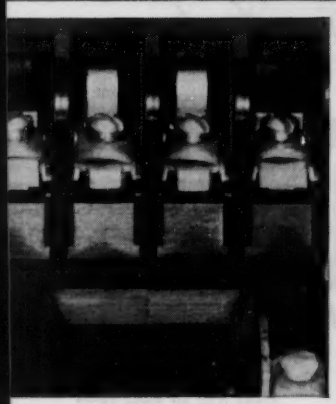
Machine tool relay is rated 6 amps, 300 volts a.c. from 2 to 8 poles in 2 basic frames. Relays can be butted against each other to save space.



Here's the new Westinghouse relay that cuts the control panel space requirements as much as 50%. Specifically designed for use on automated machine tools, this relay is smaller than any other similar unit available. Relays can be butted against each other in banks. What's more, both 4 and 8 pole frames have the same mounting dimensions, occupy the same panel area, and can be mounted adjacent to each other without additional electrical clearances. ■ Wiring a panel is easier, too. Relay terminals are all readily front accessible. Each of these clamp type connections has a wire stop . . . installation is faster and costs less. You actually save more than 20% over outdated relays. ■ This new relay has load rating of 6 amps, 300 volts a-c—found by experience to be ideal for most of the machine tools now being designed. ■ Want more information? Contact your nearest Westinghouse representative or write: Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa. Remember: You can be sure if it's Westinghouse.

Clamp type terminals are front accessible and will accept #14 to #18 stranded wire.

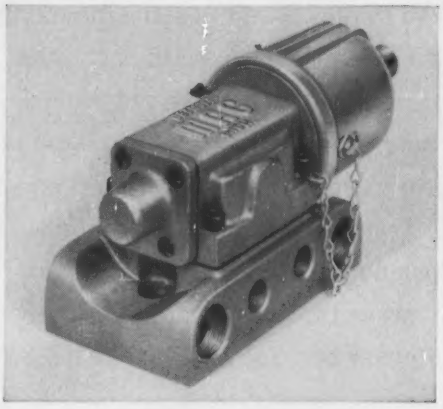
J-30318



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Westinghouse

# New Solenoid Air Valves Need No Accessories

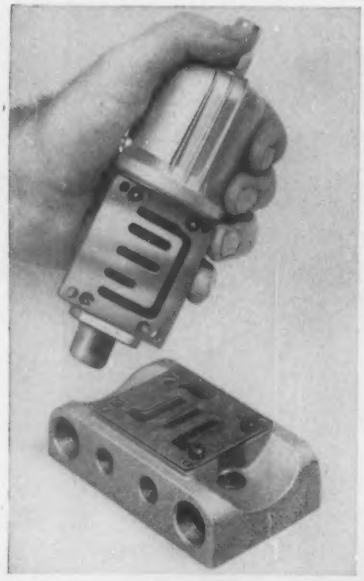


Now available for the first time are solenoid operated air valves complete with all accessories at 'bare valve' prices. Available in ¼, ⅜, and ¾ in. port sizes, they come in single- and double-solenoid types in 3-way, 4-way and 4-way 5-port models.

Features include: solenoids interchangeable on all models of a given size; pre-wired plug-in type bases, eliminating customary wiring; standardization of bodies and bases for interchangeability; unusual compactness; elimination of troublesome fasteners in solenoid assembly (which floats in rubber).

All valves are equipped with screwdriver or ball type manual solenoid operators with lock-in and lock-out feature.

Manifold type bases with common inlet exhaust, and conduit, available on ¼ in. models. For complete information, ask for MAC catalog #60.



## Plug-in Connectors Now Standard on All MAC Solenoid Valves

Pre-wired bases, into which you simply plug in the valve body, are now standard on all MAC solenoid valves—both direct-solenoid and solenoid-air types. Bases are identical for single- and double-solenoid valves of a given size.

The same principle is also applied to the "add-a-unit" manifold type bases available for all MAC solenoid valves. With these, from 2 to 10 valves can be coupled with common inlet, exhaust and conduit. Individual valves can also be isolated or pressure fed in from each end.

With plug-in leads provided on all solenoids, wiring of valves has been reduced to the utmost in simplicity.




**NEW**

Write today for this free air-valve manual and catalog.

You'll be surprised at how much time it will save you in picking just the right valve for your application. Ask for Catalog #60.

*advances in*
**PNEUMATICS**

MAC

## evolution of valve seals...

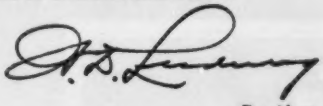
While metal-to-metal seals work well in hydraulic valves, where inherent leakage is accepted, positive leakproof sealing is mandatory in air valves. Flexible seals are today accepted as vital and they must be so designed that sealing efficiency increases with pressure. The seal should be self-cleaning so that foreign matter won't cause leakage.

At one time O-rings were thought to be the answer. O-rings are excellent for static sealing or where travel is short. O-rings are unsatisfactory, however, when used as valve seals crossing an orifice due to the shearing action.

Developing the best design and compound for air-valve seals was a long and tedious job, since elasticity, durometer hardness, compression set, and co-efficient of friction are also important factors.

Experience to date has proven that the best valve seal is a special Buna-N base self-lubricating oil-resistant compound—bonded to the metal to keep it from distorting.

This is the type of seal used in MAC valves. We believe it represents an ideal combination. At least, their amazingly long life in MAC valves seems to confirm that belief.



President

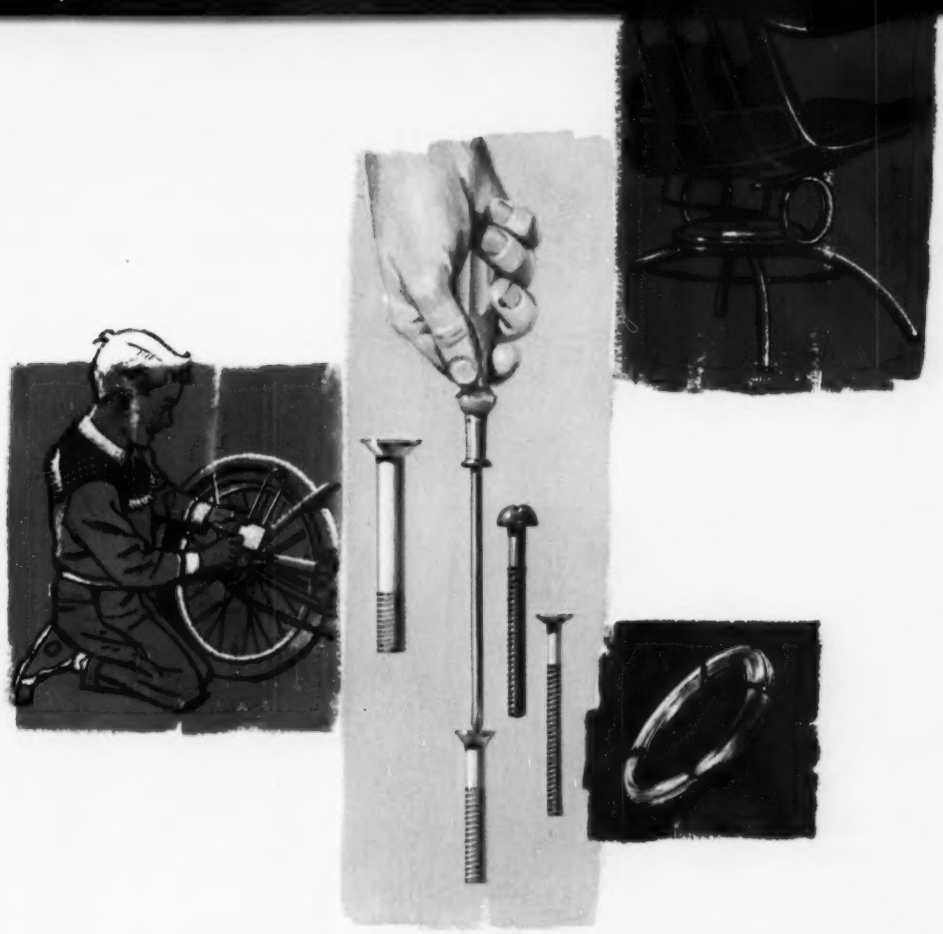
MAC

**MECHANICAL AIR CONTROLS, INC.**
10030 Capital, Oak Park • Detroit 37, Michigan

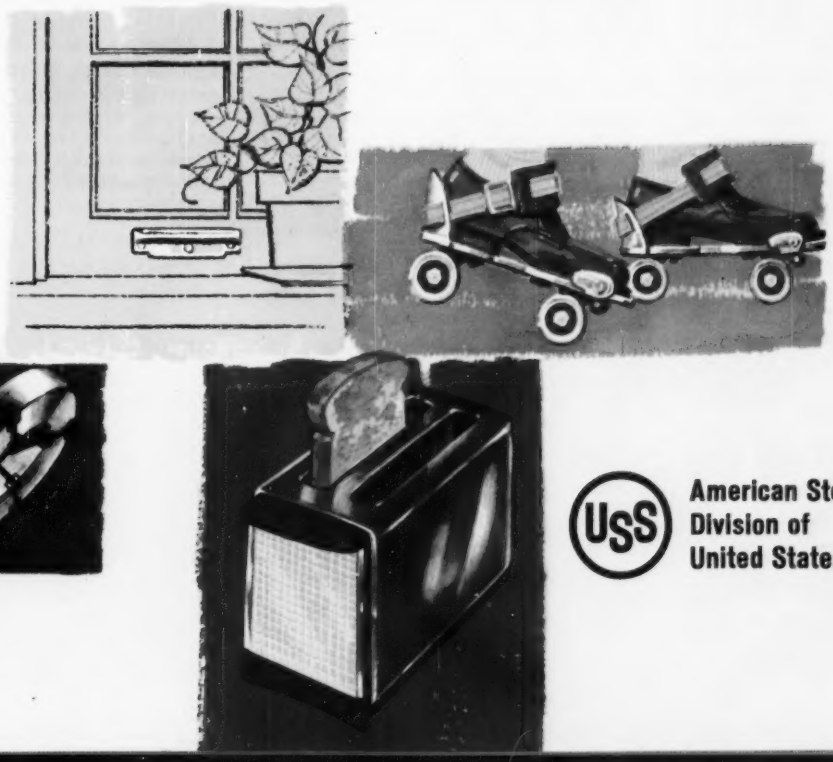


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**Quality products call for quality wire, bars and strip . . .**



USS

American Steel & Wire
Division of
United States Steel

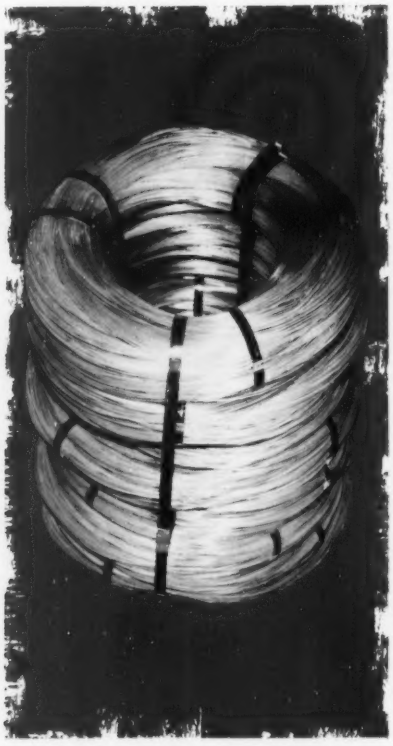
# USS American Quality Manufacturers Products packaged to speed up handling and save storage space



**Standard Coils:** American Steel & Wire manufactures standard coils in weights suited to your material handling equipment.



**Heavyweight Coils:** These continuous wire coils, weighing up to 2,000 pounds, speed up your production by reducing down time for setups and changes. One large coil takes the place of several smaller coils of same total weight—are much easier to handle . . . require much less storage space.



**Unitized Coils:** These unit packs offer great savings in handling time and storage space. One unit, containing several coils, is easily handled; takes up less storage space than the same coils stored separately.

## . . . quality controlled to help you make good products better

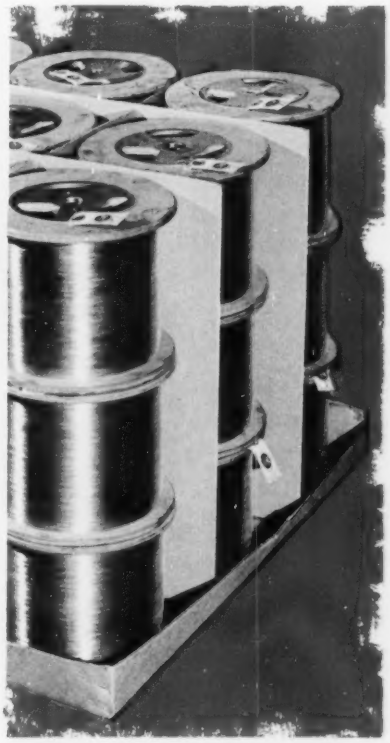


To mass produce this bicycle padlock the Master Lock Company uses USS Amer-Led Steel Bars. This leaded steel permits increased machining speed over equivalent non-leaded grades. The use of USS Amer-Led results in more accurate forming; . . . fewer rejects.

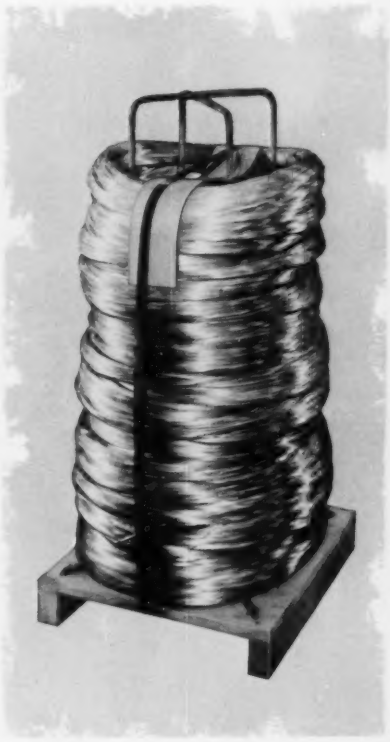
American Steel & Wire products and service facilities are available to you at no increase in cost. It will pay you to use these advantages. The quality and uniformity of USS American Manufacturers Wire brings you production economies through easier processing and fewer rejects. It makes a superior finished product that is more salable. And it is available in all the modern money-saving forms:



**Pay-off Drums:** Long-run continuous coils of wire are packed and delivered in heavy fibre containers. These Pay-off Drums are easy to handle and stack for storage. These are ideal for use where wire finish requires special protection from dirt and corrosive atmospheres. Available in most wire sizes with length and weight of coil to your specifications. You do not need to return drums.



**Disposable Spools:** These new non-returnable spools can be supplied with any amount of fine wire—from 5 lbs. to 100 lbs. These are easy to handle individually, and when shipped in quantity are delivered 36 to a pallet, ready for storage.



**Platform Coil Carrier:** The disposable platform carrier, made up of a U-shaped wire frame fastened to a platform, holds up to 3,000 pounds of special wire in one continuous length. It is often ideal for ordering and handling quantities of wire.



American Screw Company turns out 14 million recessed head fasteners a day. Their most famous patent is the Phillips Head Screw, for which American Steel & Wire developed a special cold heading wire, hard enough to produce strong, tough fasteners, yet soft enough to avoid splits and cracks when the Phillips punch is rammed into the coning blank.



The pair of round wire helical single coil torsion springs on this chair were specially made for the Homecrest Company of Wadena, Minnesota. Under a 250-pound weight, the chair was test rocked 750,000 times without showing any sign of failure. *Another success story for USS American Manufacturers Products.*

**American Steel & Wire**
**Division of**
**United States Steel**

USS

# USS Amerstrip . . . gives you precisely what you need in a cold rolled strip



**Precision Finish.** With USS Amerstrip we take special pains to give you a finish that is just right for the specific results you require in a finished product. We believe the Amerstrip finish is the finest you can get in the industry.

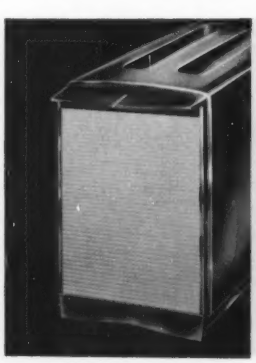


**Precisely Prepared Edges.** Because USS Amerstrip is produced in order-sized quantities engineered to your own specifications, we can give you exactly the edge finish you need—square, standard, round, full round or bevel.



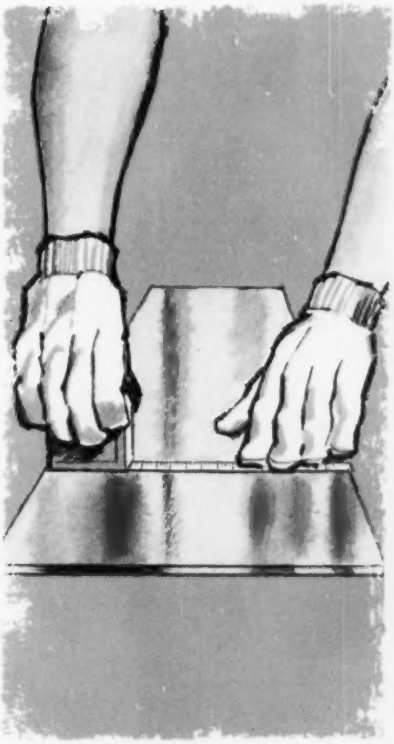
**Precise Tempers.** Whether your product must go through a deep draw or undergo other stringent forming operations, or if it requires a special temper for rigidity, you'll get the correct temper for the job when you order USS Amerstrip.

## . . . to speed up production and keep your product quality high!



Much of the sales-pulling beauty of Proctor Electric Company's modern toaster is due to the use of gold-finished, geometric-patterned USS Embossed Amerstrip. American Steel & Wire specializes in the rolling of special embossed designs such as this for specific applications. Perhaps you, too, have a product which could be made more beautiful and more sales appealing with Embossed Amerstrip.

USS Amerstrip is a specialty product that has opened vast new production and sales possibilities for a growing number of alert manufacturers of consumer products. It is available in a variety of attractive finishes—plain or embossed. It permits production on precision machines. When you use USS Amerstrip, you get six distinct advantages not easily obtainable with other manufacturing methods or materials:



**Precise Width Tolerances.** When your fabricating machines require a special width strip, you can be sure that's the width you'll get. We can produce USS Amerstrip within required tolerance limits to fit your special requirements.



**Precise Thickness Tolerances.** Whatever the thickness tolerance your machines demand, USS Amerstrip can give it to you. We can roll Amerstrip down to thickness tolerances of plus or minus .0005 inches.



**Precise Uniformity.** Regardless of the size of your order every coil of USS Amerstrip comes off the line uniform in finish, temper, width and thickness. In short, USS Amerstrip's precision production assures a continuous run and high yield.



Amerstrip is used in the manufacture of almost every part of the 15 types of Hustler Corporation skates made by Frantz Manufacturing Co. These skates will stand up under the punishing wear children may give them—yet maintain their attractive finish. Amerstrip is tailored to each particular job . . . has the physical properties to assure a good performance and efficient manufacture.



Amerock Corporation of Rockford, Illinois, makers of sash lifts, had trouble finding a strip steel that would meet its severe double drawing operation requirements. They brought the problem to American Steel & Wire. Our metallurgists recommended a type of USS Amerstrip tailored to their deep drawing requirements and capable of holding a finish suitable for plating.

**American Steel & Wire**
**Division of**
**United States Steel**

USS

# Facilities and service second to none!

As the country's largest manufacturer of wire and strip, we offer a *single source of supply* for all your varied manufacturers' wire and strip requirements.

Widespread *modern facilities* assure that your product will be made exactly to specification, thoroughly uniform in quality and dimension.

*Experienced sales representatives* are at your service to assist in determining how USS American Manufacturers Products can help make *your* product better.

For more detailed information, get in touch with the nearest district office. American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.

*USS, American and Amerstrip are registered trademarks*

**American Steel & Wire Division of United States Steel**

Steel

This mark tells you a product is made of modern, dependable Steel.




# NEW "TORTURE CHAMBER" FOR RADIAL BEARINGS

## duplicates military acceptance tests

This is a torture chamber for radial bearings. Here BCA ball bearings are run . . . hour after hour . . . under loads of 5000 pounds per bearing – matching military acceptance tests for radial bearings. This special BCA-built device is an important control and development tool. It provides essential data for BCA's ball bearing research program.

This tough performance test is an example of the greatly expanded research and testing facilities which BCA has developed for the benefit of bearings users. Reason: to provide the finest possible ball bearings to customers. Results: bearings which consistently exceed performance specifications on whatever kind of jobs they are designed for.

Among the extensive new facilities at the BCA laboratories is a Temperature-Humidity-Controlled Instrumentation Room containing precision instruments, many of which have been specially designed and modified for bearing research. There are a number of unusual testing devices, too; in design, identical to equipment in customers' plants. On these, BCA bearings can be tested *under the exact operating conditions specified by the customer.*

BCA provides a complete line of ball bearing sizes and types for nearly every kind of industry. They're standard original equipment on automotive, machine tool, earth moving, and agricultural equipment, for example. And, you'll find BCA a dependable source not only for high-performance ball bearings but engineering assistance, should you need it. For more information, contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

**BEARINGS COMPANY OF AMERICA**

ball bearings

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.



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Circle 432 on Page 19→

# How General Electric's TRI 55 CLAD motor gives you MORE THAN A MOTOR . . .




## ON-TIME DELIVERY OF THE EXACT MOTORS YOU NEED

Every order you place—large or small—for G-E Tri/Clad '55' motors is important to General Electric. Consequently, you can depend on getting just the motors you need, and on time.

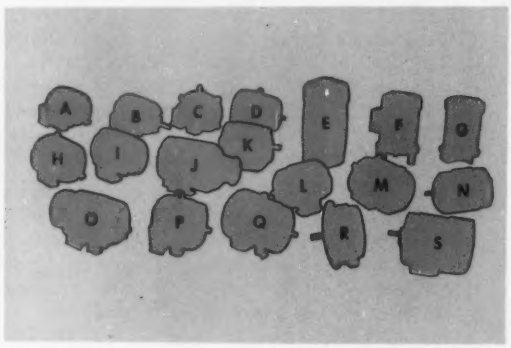
This prompt service is made possible by:

**LOCAL WAREHOUSING**—You can get off-the-shelf delivery of standard Tri/Clad '55' motors from a nationwide network of motor warehouses. Your choice of over 300 models from factory, local warehouse and distributor stock is as near to you as your telephone.

**FLEXIBLE FACILITIES**—General Electric's modern motor plants feature high-speed production lines to provide short-cycle delivery on a full line of standard and industry-specified Tri/Clad '55' motors.

Immediate availability and prompt delivery of the *exact* motors you need is General Electric's way of making your purchase truly *more* than a motor. For more information contact your local G-E Apparatus Sales Office, or write Section 840-31, General Electric Co., Schenectady 5, New York.

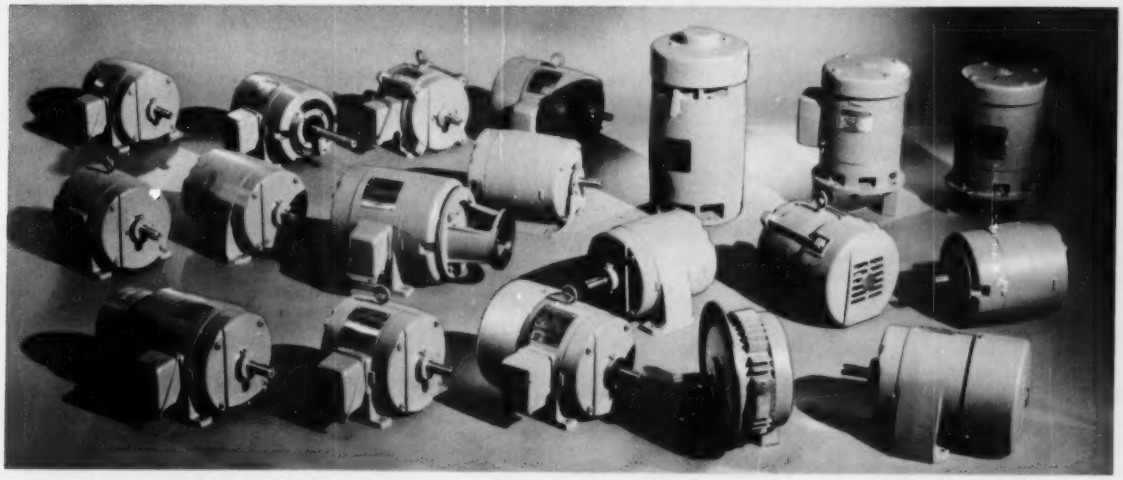
**Other "More Than A Motor" benefits of G-E Tri/Clad '55' Motors: Expert Application Aid • Constant Design Innovation • Complete Line • Fast, Local Backup Service • Durable, Long-life Performance.**



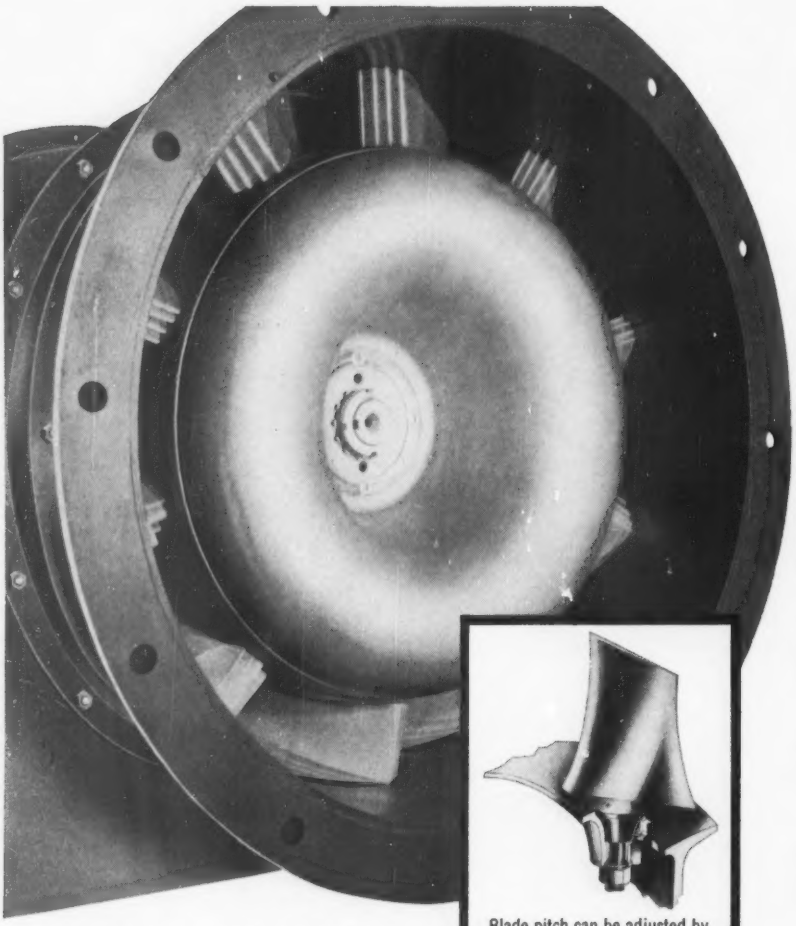

**FULL LINE** of Tri/Clad motors includes: (A) Footed dripproof, polyphase (B) C-face, close-coupled pump (C) Explosion-proof, non-vent (D) TEFC (E) Vertical, hollow-shaft (F) Vertical, solid-shaft, P-base, single-phase (G) Vertical, solid-shaft, P-base polyphase (H) Enclosed, air-over (I) Single-phase, general-purpose (J) Hydraulic pump (K) Dripproof, resilient base (L) Single-phase, farm motor (M) Explosion-proof, fan-cooled (N) C-face, round-frame (O) Brake motor (P) Enclosed non-ventilated, polyphase (Q) TEFC, severe duty (R) Thinline, enclosed (S) Fan-cooled, single-phase. All give Tri/Clad '55' motor quality.

# GENERAL ELECTRIC

**TO MEET** customer emergency requirements, General Electric Tri/Clad '55' motors are frequently shipped by air.



**A FULL-LINE OF GENERAL ELECTRIC Tri/Clad '55' motors means you can get the right motor for every application.**



Multiple exposure shows fan blades through the full range of pitch changes.



Blade pitch can be adjusted by loosening one nut, resetting the blade to desired position on calibrated scale, and retightening the nut.

*Joy Design Means:*

# MINIMUM POWER CONSUMPTION WITH VARIABLE FAN OUTPUT

Blade pitch on Joy Axivane® Fans can be adjusted easily. This means that the volumetric output of Joy fans can be varied by as much as ± 20% without any sacrifice of fan efficiency, and therefore with minimum power consumption. And with no efficiency losses such as are encountered with dampers and variable inlet vanes. (Where efficiency losses may be tolerated, the volumetric output may be changed by as much as 400%.)

Even at full load, Joy Axivane Fans are more efficient than propeller, tube-axial and centrifugal fans. The direct drive achieved by mounting the motors inside the fan housings eliminates drive losses, and the vane-axial design gives maximum aerodynamic efficiency. Mounting the motors in the housings also makes the Joy Axivane Fans more compact, and less costly to install.

Fans available range from types which weigh as little as a pound and have a diameter of a few inches, up to some which weigh tons and have diameters up to twelve feet. If you need spot cooling, area ventilation, or any movement of air, Joy can supply the most efficient answer.

For complete information, write for Bulletin 1198-64B.



**AIR MOVING EQUIPMENT FOR ALL INDUSTRY**




**JOY**

**Joy Manufacturing Company**
**Oliver Building, Pittsburgh 22, Pa.**

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario



Circle 433 on Page 19

first in silicones

Dow Corning

# SILICONE NEWS

for design and development engineers • No. 77

## NEW ADHESIVE FOR SILICONE RUBBER

**Now Available: Silastic 140 Adhesive, a new type of silicone adhesive for bonding silicone rubber parts to steel (cold rolled or stainless); aluminum; copper; glass surfaces; Teflon or neoprene; and such plastics as phenolic laminates, methyl methacrylates and silicone resin laminates. Also bonds silicone rubber to itself.**

Easy to handle and apply, Silastic 140 Adhesive requires no heat or pressure . . . produces a bond that's stronger than the silicone rubber itself, is heat-stable, and shows good resistance to oil and water.

Silastic 140 Adhesive makes it possible to bond Silastic parts to materials that cannot tolerate heat or to surfaces in areas where heat could not be applied.

For more information on Silastic 140 Adhesive, please circle . . . . . *No. 241*

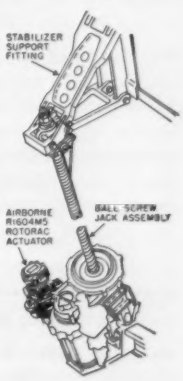




## SAVES SPACE AND WEIGHT

**An excellent example of the trend to compact, lightweight power drives is provided by the special actuator developed by Airborne Accessories Corporation, Hillside, New Jersey for trim systems on the Boeing 707.**

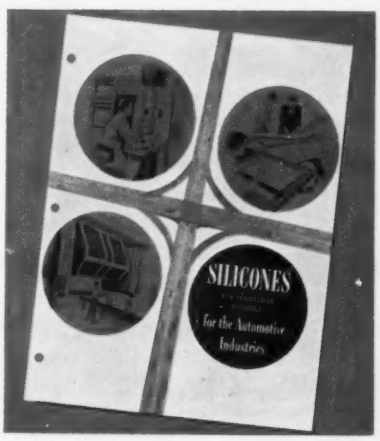
Airborne uses a variety of miniaturization techniques. One of their most important tools in making smaller, more reliable drive motors, however, is Dow Corning silicone insulation. The use of silicone insulation on these high performance motors assures utmost reliability under almost continuous off-on-reverse type operation . . . helped designers provide up to 50% more power per pound . . . helped them tailor performance of the motors against inertia of all rotating parts and load. This silicone insulated actuator has a 4.25 inch frame, weighs only 13.2 pounds with brake, is rated continuously to 2.5 hp, 11,000 rpm, and intermittently to 6 hp, 9,000 rpm.




Another drive motor that Airborne engineers have designed to be lighter, more compact and more reliable through the use of silicone insulation . . . a specialized compressor motor weighing a mere 8.8 pounds . . . delivers 1.7 hp output continuously at 10,900 rpm and in ambient temperatures up to 160 F. *(Cont. Pg. 2)*

## Silicones in the Automotive Industries

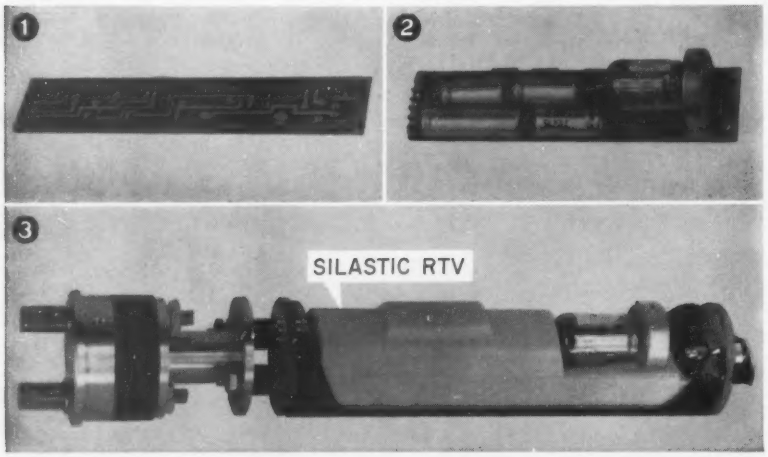
**How silicones, with their somewhat higher initial price, gained widespread acceptance in the cost conscious, high volume automotive industries may well be the materials success story of the last decade. But whether it is or is not the story, it makes interesting and stimulating reading in the new 8-page reference, "Silicones For The Automotive Industries", just released by Dow Corning Corporation.**




Colorful and well illustrated, this new brochure describes how silicones in various physical forms are helping designers of autos, trucks and other land vehicles solve some of their most difficult engineering problems. Applications for silicone products in production equipment *(Cont. Pg. 2)*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

MORE




# PACKAGES AND PROTECTS

**How best to "package" high gain preamplifier components for severe duty service within strict space limits? Vitro Laboratories, Silver Spring, Maryland, found the answer to be encapsulation with Silastic® RTV, the fluid silicone rubber that cures at room temperature.**

Vitro Laboratories' preamplifier consists of a vacuum tube and three transistor stages containing a total of twenty-five parts. Design specs called for a neat package no larger than 1-7/16" diameter by 5" long. Desired operating characteristics: high insulation strength, heat stability, and resistance to shock, vibration and moisture.

All of these requirements are met conveniently and easily by Vitro engineers through mounting the components on a printed circuit board, then encapsulating the board and all with Silastic RTV.

The procedure is simple. After securing all components and testing them, the board is placed in a two-piece plaster mold. A "window" is blocked out to permit easy access to the vacuum tube. The fluid Silastic RTV is then poured into the assembly in a slow, steady stream until the mold is completely filled. A moderate amount of heat speeds vulcanization so that the unit is completely cured in two hours and requires a minimum of trimming.

Silastic RTV provides a "professional-looking" package . . . and more important, it soaks up shock and vibration, dissipates heat and effectively locks out moisture. It retains its fine physical and dielectric properties under adverse environmental conditions. By exerting a firm grip on preamplifier components, Silastic RTV eliminates the need for a number of space-consuming clamps and brackets. Another feature: The resilient silicone rubber allows easy tube replacement. *No. 242*

**AUTOMOTIVE** *(Continued)*

and as aids to manufacturing and maintenance are also outlined.

While prepared especially for designers of autos and auto production equipment, this new reference will be of interest to engineers in any field because it explains how the properties and forms of silicones combine to make possible new concepts and new freedom in design engineering.

For a free copy of "Silicones For The Automotive Industries", circle . . *No. 243*

**SILICONE INSULATION** *(Continued)*

Airborne further assures the reliability of its specialized drives by using closely toleranced motor bearings featuring heat-stable and noncorrosive silicone lubricants which exhibit an extremely low viscosity characteristic at —65 F. *No. 244*

## new literature and technical data on silicones

**Flight Designs** — The rapidly expanding uses for silicones in aircraft and missile design are described and illustrated in a new brochure, Silicones Solve Space Age Problems. Thirty application stories, each with detailed illustration, graphically demonstrate advantageous uses of such silicone products as compounds, fluids, lubricants, protective coatings, rubbers, resins, potting materials and sealants . . . provoke thinking how designers may adapt these versatile engineering materials to improve performance, make good products better. *No. 245*

**Design Versatility** — Lightweight, strong, inert, and easy to fabricate, silicone-glass laminates are used in the design and manufacture of a variety of consumer and industrial products. Applications, tables of physical and dielectric properties, illustrations of various parts, and sources of silicone-glass laminate parts are included in a four-page brochure. *No. 246*

**How Silicones Work for the CPI** — This manual is the first and only description of silicones for the chemical process industries. It cites how various forms of silicones help design, process and maintenance engineers expand capacity, cut costs, increase reliability, and improve job conditions. Here's a management tool that's a must for all engineers in all phases of the CPI. *No. 247*




**Tapes That Stick** — Dow Corning silicone pressure-sensitive adhesives make tapes stick to anything. They help achieve serviceability over a wide range of temperatures, resistance to oxidation, weathering, corrosive chemicals, and retention of good dielectric properties. For complete information on the properties of tapes made with Dow Corning silicone adhesives, and their applications, circle . . . . . *No. 248*

**Compiled for Advanced Research** and development engineers, an eight page reference provides a convenient guide to selecting the most suitable silicone fluid medium when designing damping, springing, coupling and related mechanical devices. Includes tables, graphs and detailed information about properties that enable Dow Corning silicone fluids to increase efficiency of existing designs and make possible new design changes. *No. 249*

Dow Corning Corporation, Dept. 4909, Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248 249

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

**SILICONE NEWS** is published for design and development engineers by

first in silicones

**Dow Corning CORPORATION**
MIDLAND, MICHIGAN

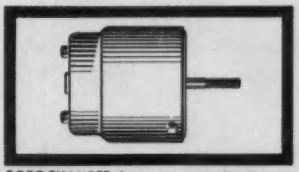
ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST GOBAIN, PARIS

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE IN COUPON ABOVE, OR REFERENCE NUMBER ON READER SERVICE CARD

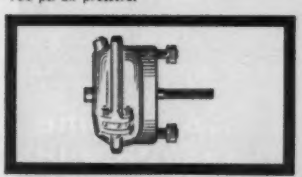



# Fast, Dependable Deliveries Bendix-Westinghouse Power Cylinders

A complete inventory of machined parts—plus unusual manufacturing flexibility—permits us to fill our customers' power cylinder orders *fast.* In emergencies, we have even made same-day deliveries. Furthermore, our broad industrial design and application experience assures you of getting power cylinders exactly tailored to *your* needs. Bendix-Westinghouse piston-type cylinders operate up to 200 psi air and 1800 psi oil and are available in many specialized sizes and mounts as well as in a broad range of standard models. Ask for complete information on industrial products designed and manufactured by Bendix-Westinghouse.



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 psi air pressure.



ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

**Bendix-Westinghouse** BW

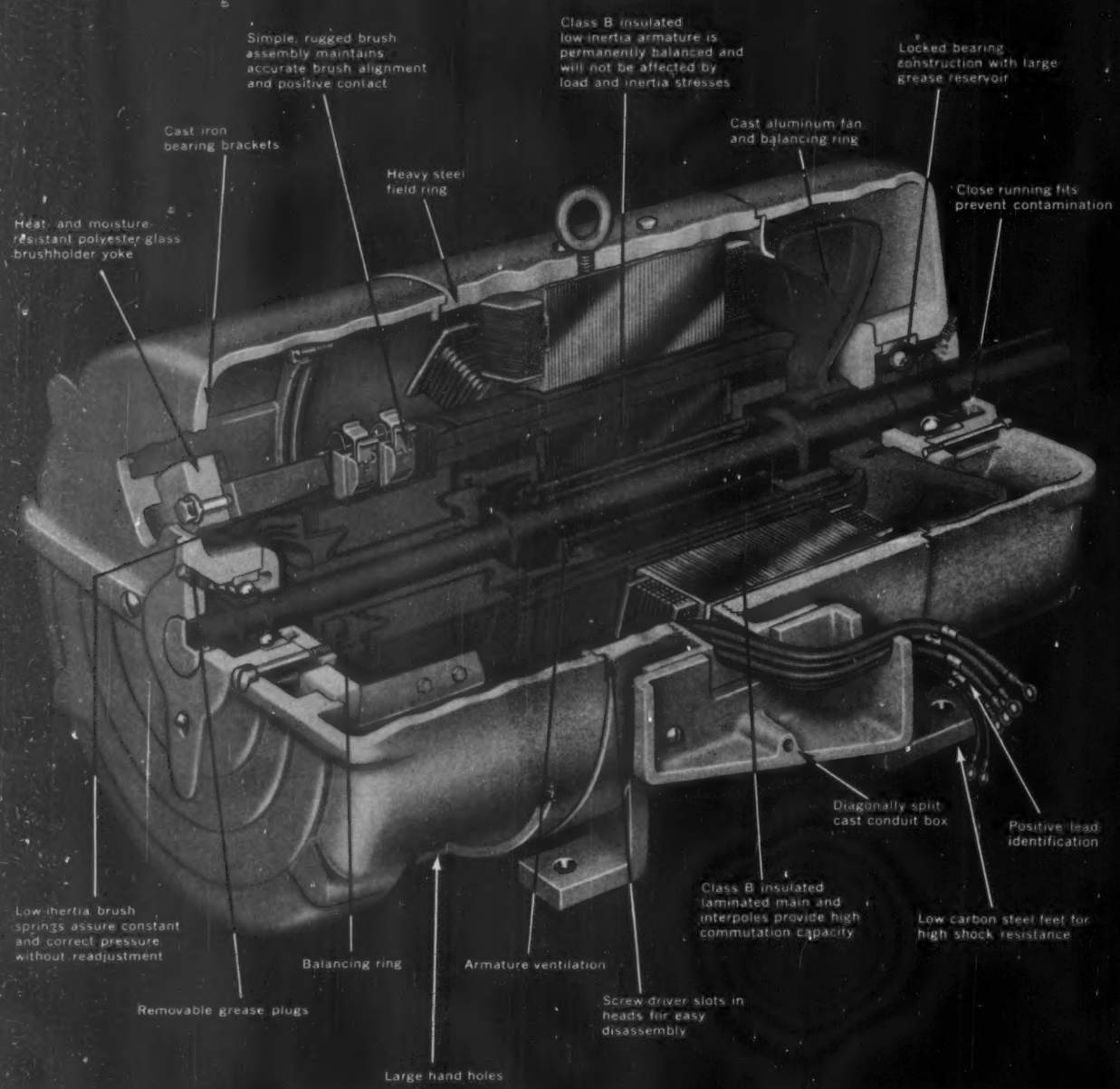
INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

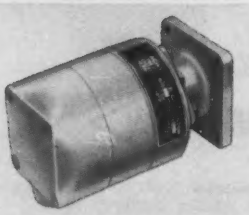


Circle 434 on Page 19

# Here's the latest in D-C motor design:




## ...and some easy-to-add field modifications



**A-c tachometer for speed indication**



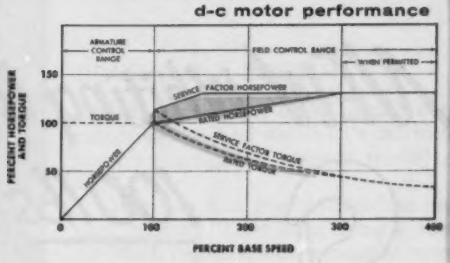
**A-c motor-driven blower with permanent dry-type filter for easy mounting on bearing bracket**



**Magnetic disc-type brake with d-c series or shunt, or a-c coils**

*Another new product from Louis Allis*

**FLEXITORQ sets new standards for d-c motor performance**




**LOUIS ALLIS FLEXITORQ MOTORS**

- are rated 60° C rise for continuous operation
- provide 1.15 service factor operating at base speed, and 1.30 service factor at 150% to 300% speed
- may be operated from 300% to 400% of base speed at 130% load with 1.0 service factor, where size permits
- short-time overloads of 400% can be commutated at base speed and below

# New Louis Allis FLEXITORQ® D-C MOTORS

## ...offer you vastly improved commutation– low brush wear–400% short-time overload capacity– and unmatched flexibility!

Bear this in mind: The Flexitorq is *not* just another *re-rated* d-c motor. It's *all new* — and it's been designed to give you more for your power dollar — in superior performance, matchless field flexibility, and unrivalled economy of operation and upkeep.

Advanced armature design and brush construction offers improved commutation, faster response, and lower brush wear. Class B insulation system provides exceptional thermal endurance . . . is rated for 60° C rise for continuous duty . . . and creates a barrier to moisture, acids, alkalis, and other abrasive and corrosive contamination.

The net result to you is reliable, trouble-free power for constant and adjustable speed drives. For example, Flexitorq gives you 400% faster acceleration, plus much better deceleration, reversing, and speed changing. You can safely impose 400% intermittent and 15% continuous overloads — and the high-torque design is a welcome plus when you need extra power for hard-to-start machines.

The new Louis Allis Flexitorq is lighter and more compact than previous d-c motors . . . lets you squeeze more power into less space . . . yet is actually *easier* to service! Brushes and entire brush-holder assemblies can be quickly inspected and removed without major disassembly. And since brush springs remain conveniently attached to the brush holders, brush changing is a simple affair.

Flexitorq d-c motors are available in sizes from 1 to 400 hp — in various enclosures. See your nearby Louis Allis District Office for information and application help. Or write for Bulletins 3150 and 3200 to The Louis Allis Co., 459 E. Stewart Street, Milwaukee 1, Wisconsin.



Helical single, double, and triple reduction gear units for all ratios

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

**LOUIS ALLIS**

DC-216

Circle 435 on Page 19

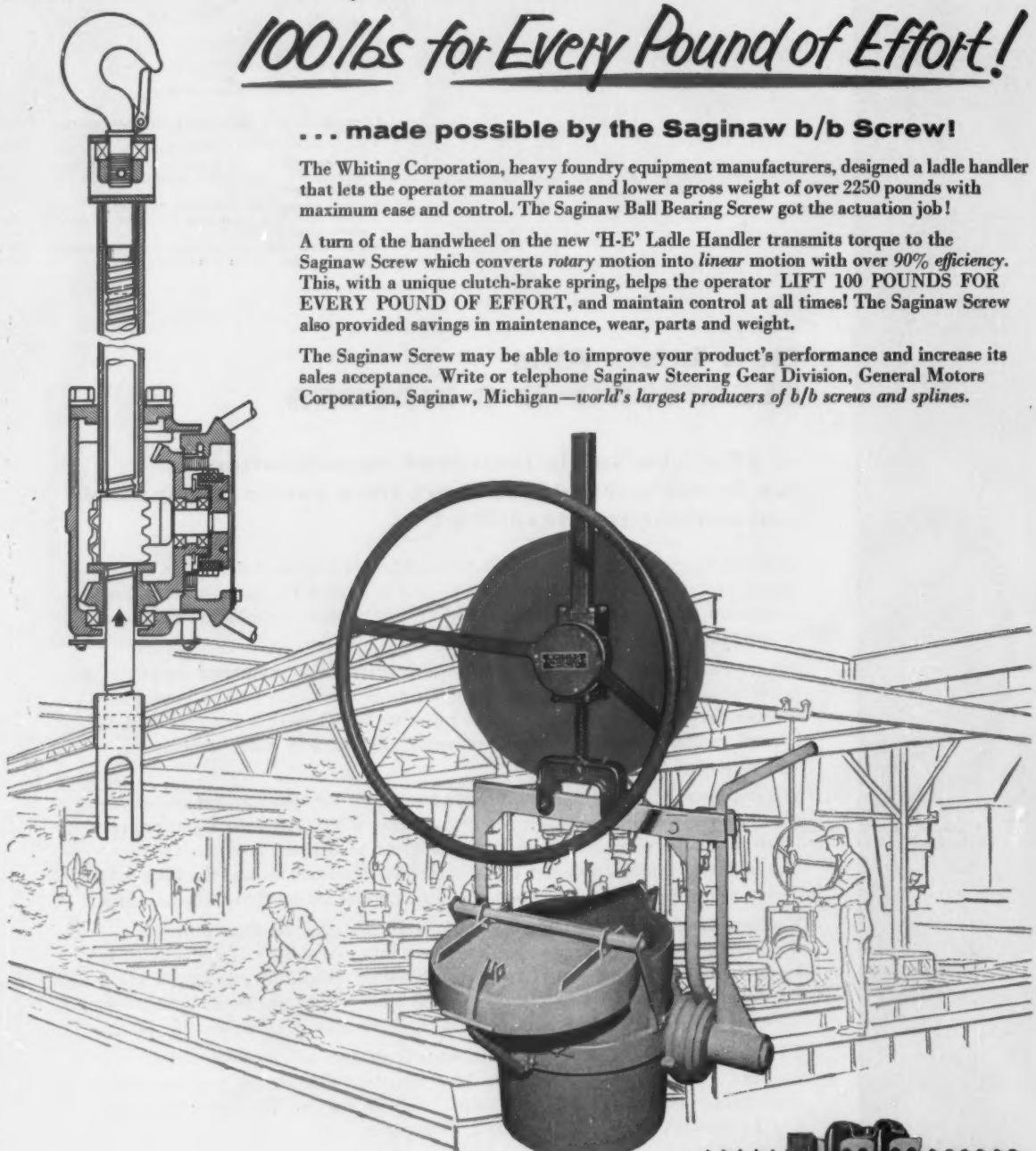
# NEW Whiting Ladle Handler Lifts 100 lbs for Every Pound of Effort!

## . . . made possible by the Saginaw b/b Screw!

The Whiting Corporation, heavy foundry equipment manufacturers, designed a ladle handler that lets the operator manually raise and lower a gross weight of over 2250 pounds with maximum ease and control. The Saginaw Ball Bearing Screw got the actuation job!

A turn of the handwheel on the new 'H-E' Ladle Handler transmits torque to the Saginaw Screw which converts *rotary* motion into *linear* motion with over *90% efficiency*. This, with a unique clutch-brake spring, helps the operator LIFT 100 POUNDS FOR EVERY POUND OF EFFORT, and maintain control at all times! The Saginaw Screw also provided savings in maintenance, wear, parts and weight.

The Saginaw Screw may be able to improve your product's performance and increase its sales acceptance. Write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*





***Actuation To Fit Your Individual Requirements***

Have been built as small as 3/16 in. B.C.D. and ¾ in. long, as large as 6 in. B.C.D. and 40 ft. long. Larger sizes can be built to your order.

**Saginaw**

**ball bearing Screw**

**WORLD'S MOST EFFICIENT ACTUATION DEVICE**

*Product-Design*
**BRIEFS**
*from Durez*

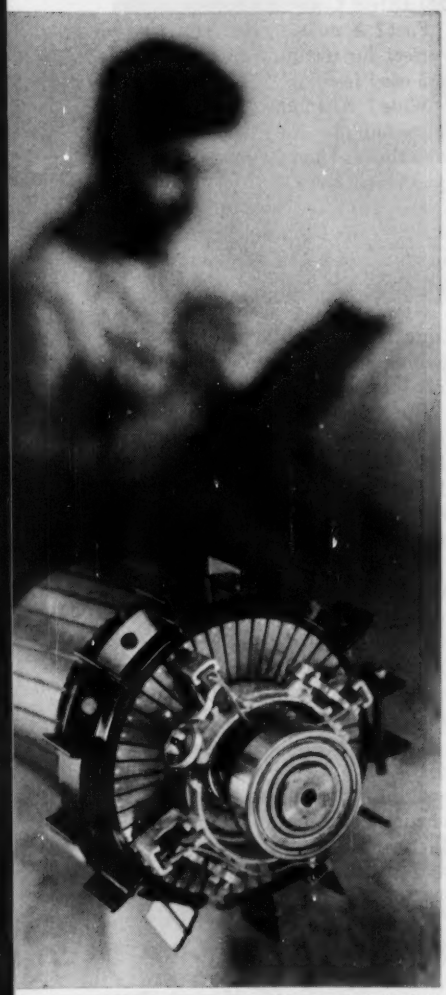
## MIND OVER MOTOR

This phenolic fan will help an electric motor run cool and quiet for years to come.

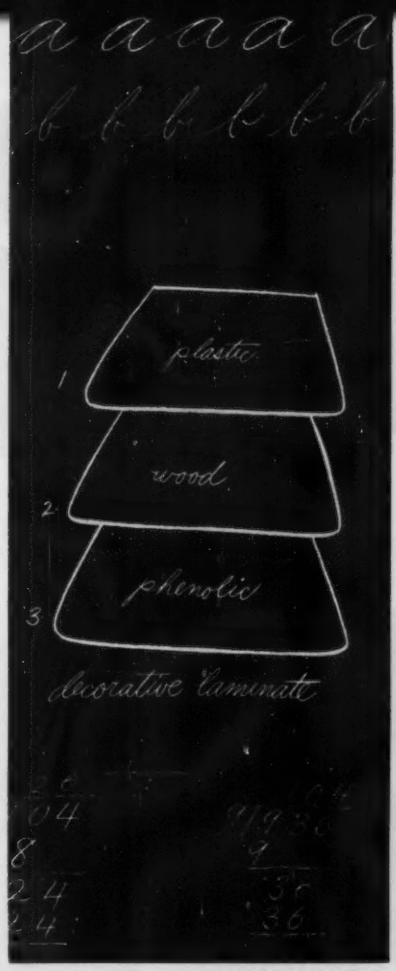
It won't warp out of shape if the motor toils for hours in the hot sun or sits idle for days in a damp cellar. It won't rattle or hum.

To the men who make the motor, it means a better product; the right blade contour with no machining. Precise concentricity and balance, molded in. Light weight.

Perhaps you could use these advantages of Durez phenolic in one of your products. Your custom molder will be glad to talk with you about it.



THE BROWN-BROCKMEYER CO.




DECAR PLASTIC CORPORATION

## LESSON IN LAMINATES

Think back—to a classroom of desks with varnished ink-stained tops gouged with the initials of your predecessors.

Then think ahead, as the makers of school furniture are doing. They use tough plastic Decarlite desk-top sandwiches—laminates that take pupil punishment in stride. The best of these have a layer of Durez phenolic in them.

Lesson for today: if you want a laminate to be stiffer and harder, to be dimensionally stable, to last longer and hold its shape better, think of Durez phenolic resins. They're low in cost. They bond, impregnate, harden—and stay that way for keeps. If you'd like to know more about what these versatile resins can do for you, write us describing the problem.

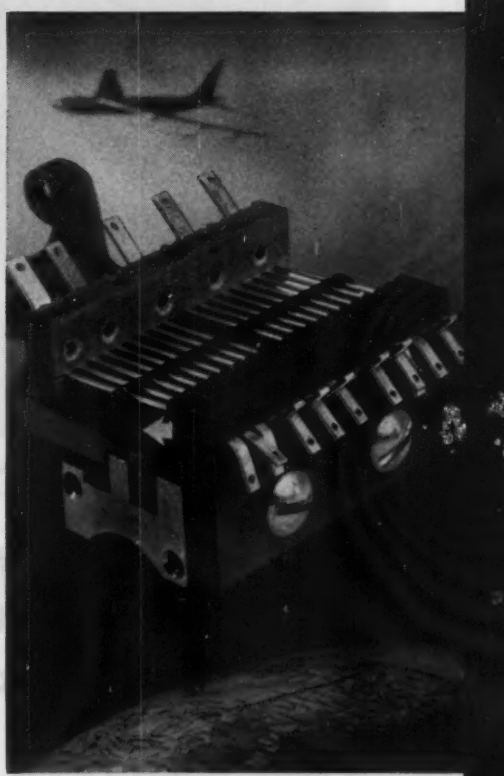
## BRAIN FOR A BOMBER

This is a read unit of a latitude data computer, part of the B-52's intricate bombing-navigation system made by IBM.

Engineers had trouble molding one part (arrow). They were using a plastic which required a high molding pressure. This high pressure damaged the steel part of the pin assembly by forcing it into the locating portion of the mold.

A switch to a Durez diallyl phthalate molding compound was the answer. This material molds at lower pressures and provides the right physicals with virtual freedom from cold flow and creep.

When you want reliability in a system—with no room for compromise—a Durez diallyl phthalate compound may be your solution, too. For data on these premium-quality materials, write us or check the coupon.



IBM FEDERAL SYSTEMS DIVISION

**For more information** on Durez materials mentioned, check here:

- ☐ Phenolic molding compounds—descriptive Bulletin D400
- ☐ Phenolic resins—illustrated bulletin describing uses
- ☐ Diallyl phthalate molding compounds—data sheets

**Clip and mail** to us with your name, title, company address.
*(When requesting samples, please use business letterhead.)*

**DUREZ** PLASTICS DIVISION

509 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

*Circle 436 on Page 19*

# OZALID NEWSLETTER

*NEW IDEAS TO HELP YOU WITH ENGINEERING REPRODUCTION AND DRAFTING*



A simple sponge with new Duratrace
is your quickest way to renew soiled drawings.

## New washable, scrubbable Duratrace® gives you indestructible masters you can sponge new!

If ever there was a drafting film that "is forever," Duratrace is it. New Ozalid Duratrace, when used with modern plastic pencils, can be wiped clean and thereby restored to new condition at the sweep of a sponge. Drawings, originally done in regular pencil or India ink, can also be cleaned, although a bit more care might be necessary.

Just combine this cleanability with the fact that Duratrace never yellows or ghosts, and you've got a winner that's hard to match on any count. And how about *this? Duratrace either exceeds or equals any other tracing material as far as dimensional stability is concerned!*

Want even more? Just check Duratrace on acceptability of a pencil image! Never has a drafting film equaled New Ozalid Duratrace on pencil acceptability. But the proof is really in the doing. There are intangibles that exist between a draftsman and his materials that are hard to fully describe. Only your own experience with Duratrace can completely convince you. We think that Duratrace has a certain "feel" that makes it a delight and a joy to work with. Hundreds of draftsmen agree with us. Why not try Duratrace today? Someday, someone might improve on this. Bet we'll be the ones to do it. On every count, doesn't it make sense to try Duratrace?

### If you like 'em stacked for speed...

Just check our Ozalid Streamliner 200 Direct Copy Machine.

Fast? A neat 14 feet per minute. Perfect for medium-sized operations and easy feeding.

Wide? A roomy 42 inches that takes four 8½ x 11 sheets in a row, does them as fast as smaller machines do a single sheet.

And the new close-up controls of the 200 cuts operator fatigue; means anyone can learn to operate it in minutes.

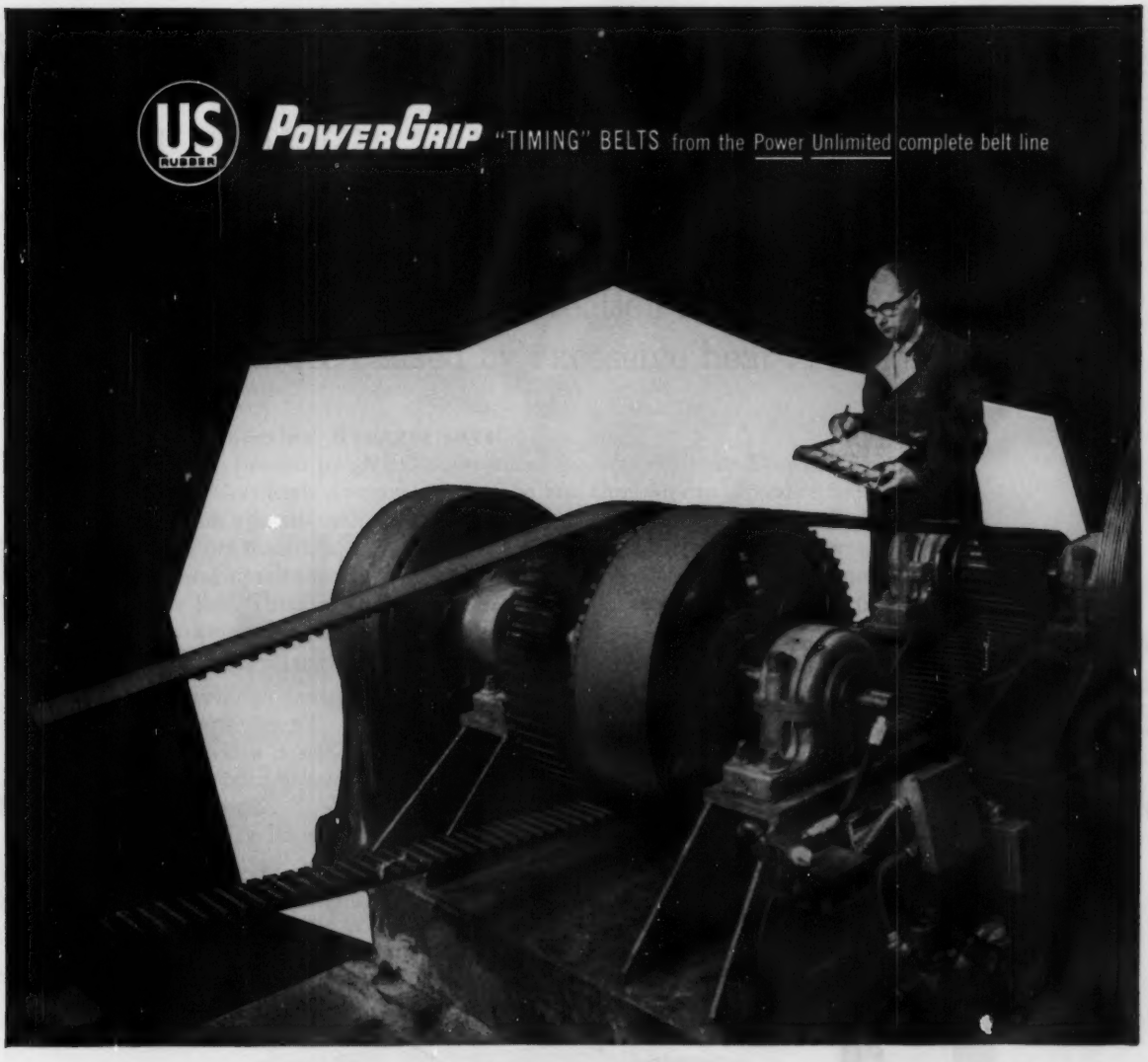
New stacking system cuts work time considerably while the new cooling system means greater comfort for everyone in the office.

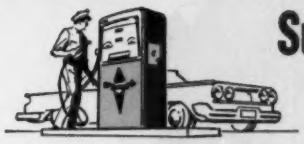
But these are just the basic facts of operation. How about versatility? The Streamliner 200 is specifically designed as a double-duty unit equally suitable for both engineering and general office work.

Just invest in one Streamliner 200 and get both an engineering *and* an office unit in one. You get the benefits of engineering speeds and width in your technical work *plus* a super high-efficiency unit for office copying and order invoicing.

One last plug. The Streamliner 200 costs a lot less than you would imagine. It costs less to operate and virtually nothing to maintain. Sold? Just contact your local Ozalid representative for a demonstration.

***Ozalid,** Johnson City, New York. A Division of General Aniline & Film Corp.*



# Sun Oil Company obtains positive results with U.S. PowerGrip "Timing" Belts

The octane requirements for cars are determined by the Sun Oil Company with scientific accuracy. The octane ratings of motor fuels are in turn determined with precision. Nothing is left to chance. This is why the motorist can pull up at a Sunoco station and obtain the correct octane blend for his car.

All of this predetermination is done on precision equipment whose universal joint drive shaft is connected to a dynamometer by a 1¼" pitch U. S. Rubber PowerGrip "Timing"® Belt. In the words of a company scientist, these belts were selected because they give foolproof, positive drive transmission and do not require lubrication, maintenance or attention. Anything less would interfere with the precision of the testing equipment. This is the experience that has caused innumerable design engineers to specify PowerGrip.

This is the belt that has made possible the development and production of hundreds of appliances and equipment, ranging from sensitive electronic devices, office machinery, household equipment and gigantic production machinery. One way to get expert and instant power and transmission advice is from the U.S Distributor.

US RUBBER

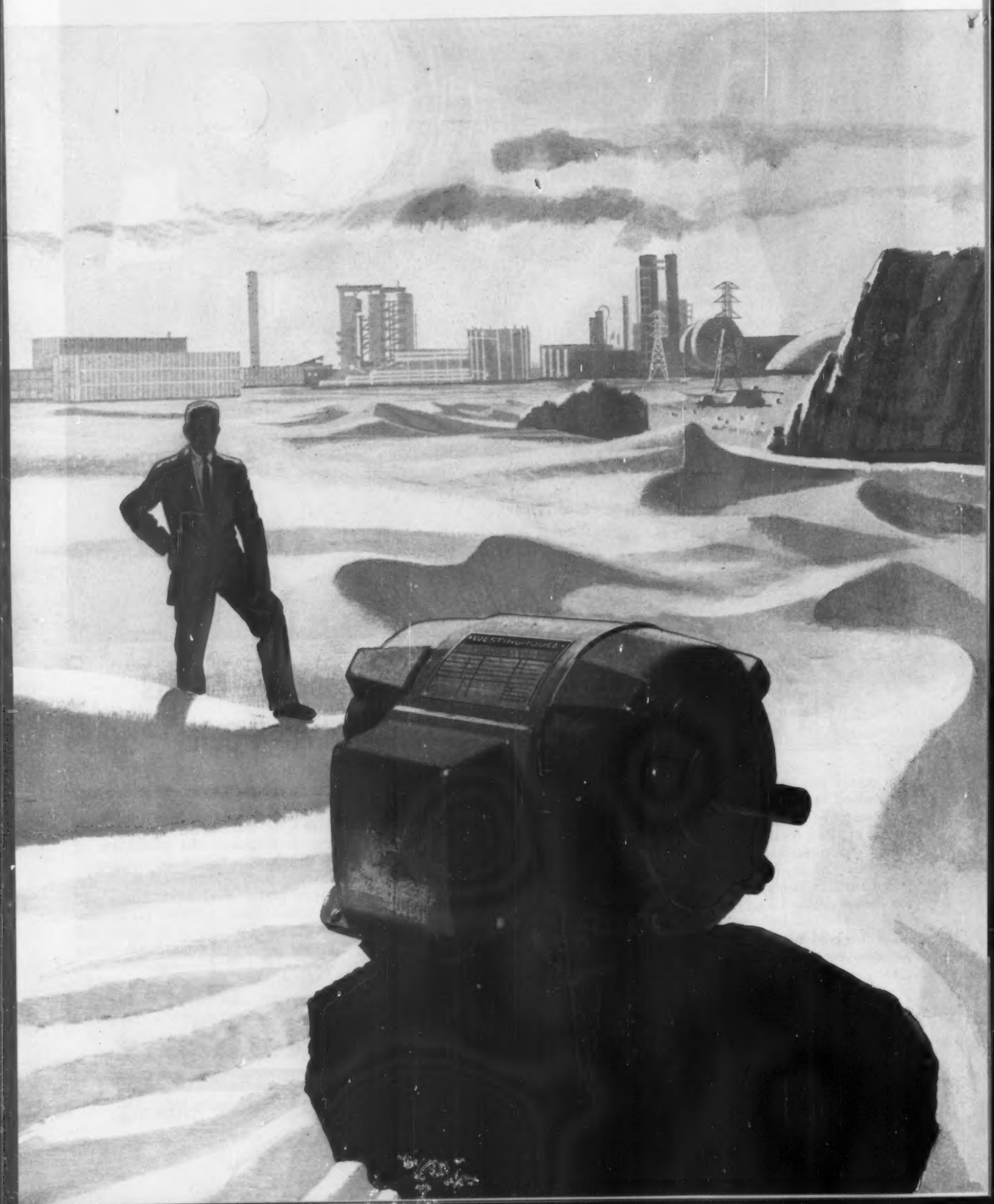
Mechanical Goods Division

**United States Rubber**

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

NEW WESTINGHOUSE *Guardistor*



# MOTORS LET YOU USE ALL THE HORSEPOWER YOU PAY FOR...SAFELY

## The man and the motors from Westinghouse now provide absolute protection against motor failure caused by excessive heat . . .

**Our Engineering Manager says:**
"With the breakthrough development of the Westinghouse Positive Temperature Coefficient thermistors, for the first time we can provide inherent protection against motor failure caused by excessive heat. The solid-state thermistors buried in the windings instantly sense excessive heat from any cause and simultaneously warn of trouble or automatically take the motor off the line. Thus, motor protection is placed where only true motor protection can be . . . in the windings."

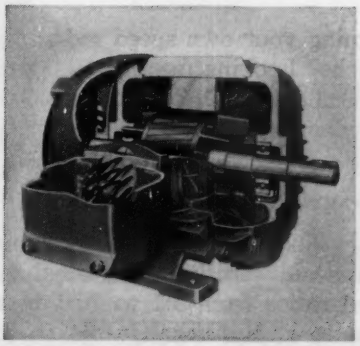
**Our Marketing Manager says:**

- "You can match the motor to the load . . . use all the motor you are paying for.
- Provides positive protection based on winding temperature . . . *not* load current and/or power supply fluctuations.
- Eliminates time and expense of changing winter-summer heaters. No nuisance tripping, it's fail-safe . . ."

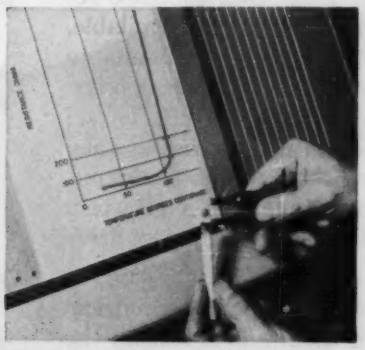
Call your Mr. Westinghouse for the application of a Guardistor* motor to your drive requirements . . . write for *Questions and Answers About . . . Guardistor* (B-7876). Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. You can be sure . . . if it's Westinghouse.

*Trade-Mark

J-22160-R



Unlike remotely located sensing devices, PTC thermistors are buried in the windings of the Guardistor motor, instantly equating all temperature factors.



Ever alert PTC thermistors constantly totalize temperature, statically triggering an action *only* if critical temperature is reached.

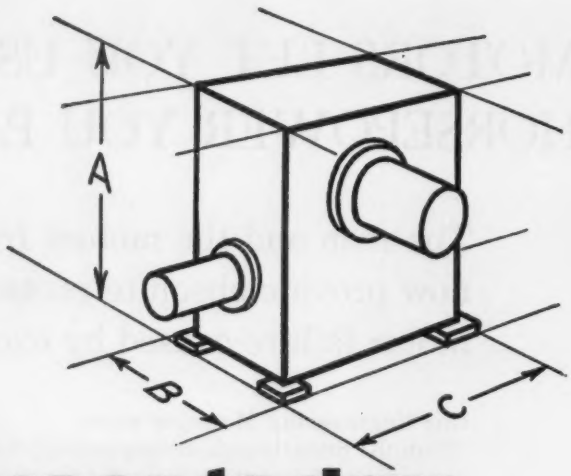
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Circle 439 on Page 19

(Advertisement)

## Do-It-Yourself...




# Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

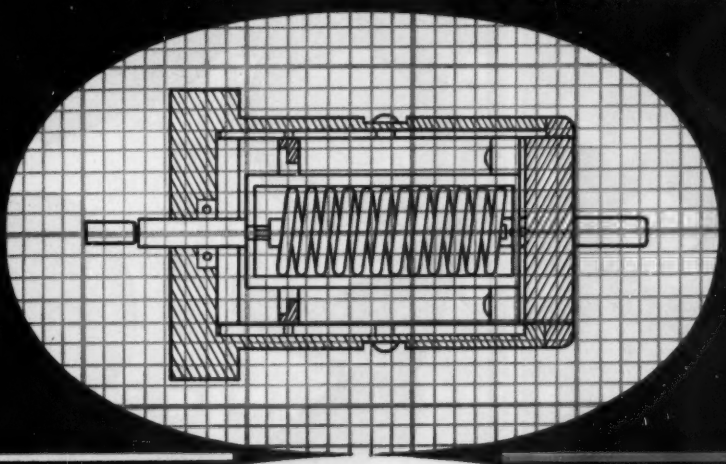


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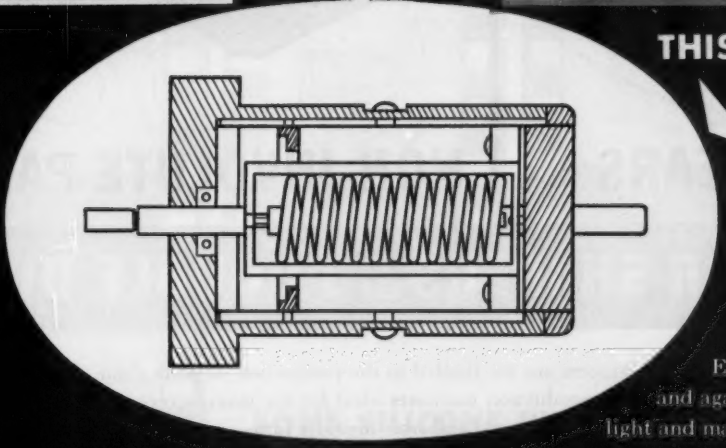
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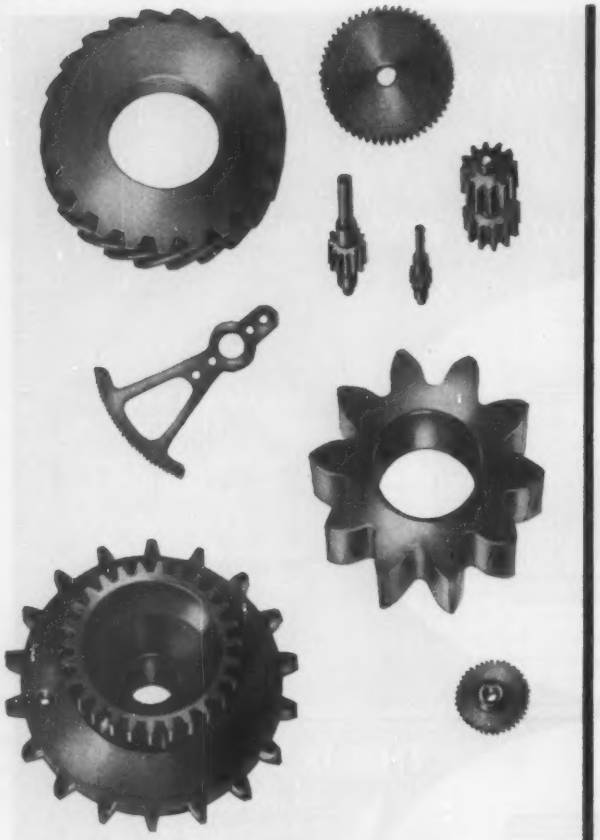
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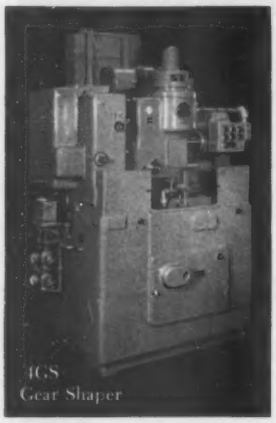


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NON-INVOLUTE PARTS

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No. 1GS Gear Shaper

Fellows Gear Shapers are not limited to the production of gears alone. They are valuable production machines ideal for the manufacture of many types of parts, of both involute and non-involute form.

As gear shapers, they provide high production rates in the manufacture of internal and external spur and helical gears. As general purpose production machines, they also make possible the economical production of irregularly shaped parts . . . in many cases doing in one simple operation what would require several operations using conventional shop tools.

Your Fellows representative will gladly give you the facts on how the complete Fellows line of production and inspection equipment helps increase production and cut costs. Ask him, or write direct.

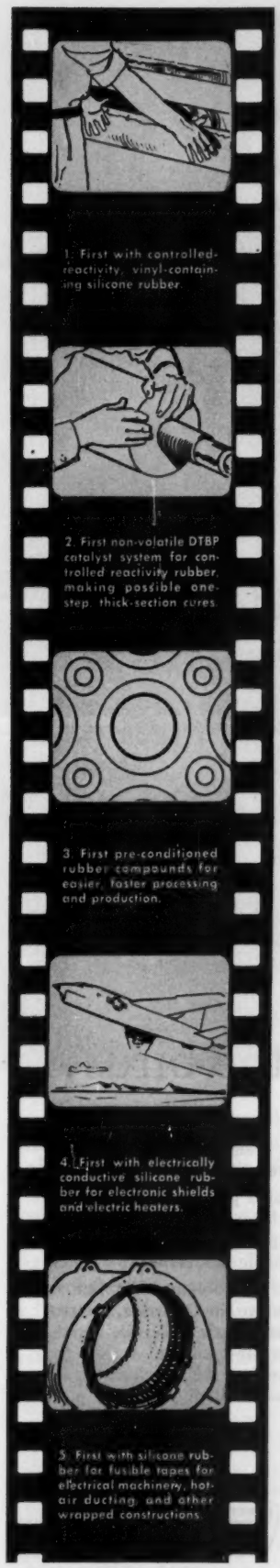
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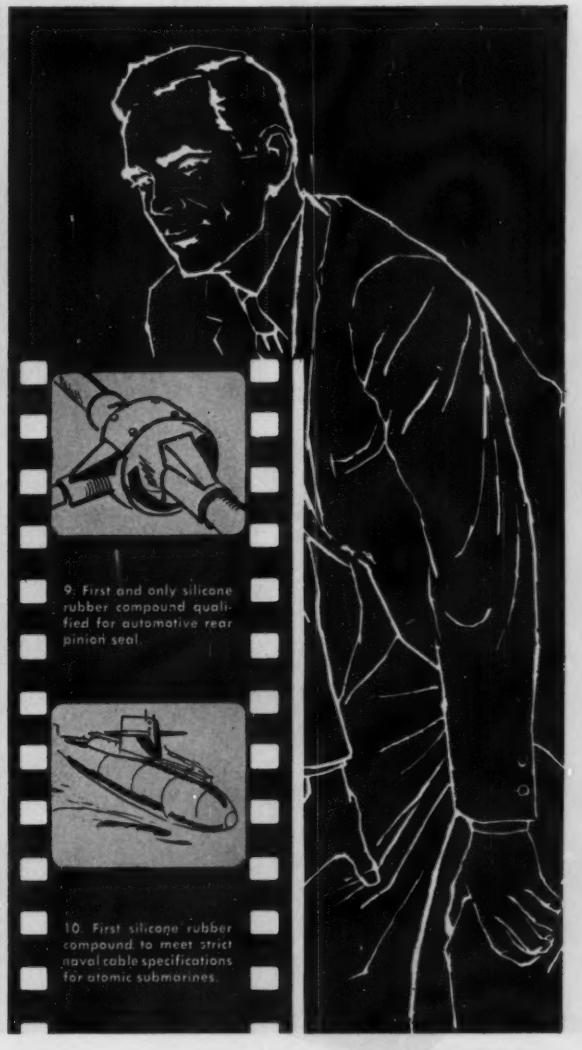
Fellows

*Gear Production Equipment*










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The combined technical and research facilities of Union Carbide Corporation, with tremendous resources of chemical experience and knowledge, have brought about outstanding achievements in silicone rubber. Ten of these contributions, which industry has enthusiastically accepted, are depicted on our film strip here.

**Important thing to remember:** Whenever you need the strikingly superior advantages of silicone rubber, see your UNION CARBIDE Silicones Man first. Advantages such as low temperature flexibility, thermal and oxidation stability at very high temperatures; low compression set; weather, ozone, oil resistance; electrical resistance or conductivity. Your Silicones Man has them all at his fingertips. Write Dept. IL-9002, Silicones Division, Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y. *In Canada:* Union Carbide Canada Limited, Bakelite Division, Toronto 12, Ontario.

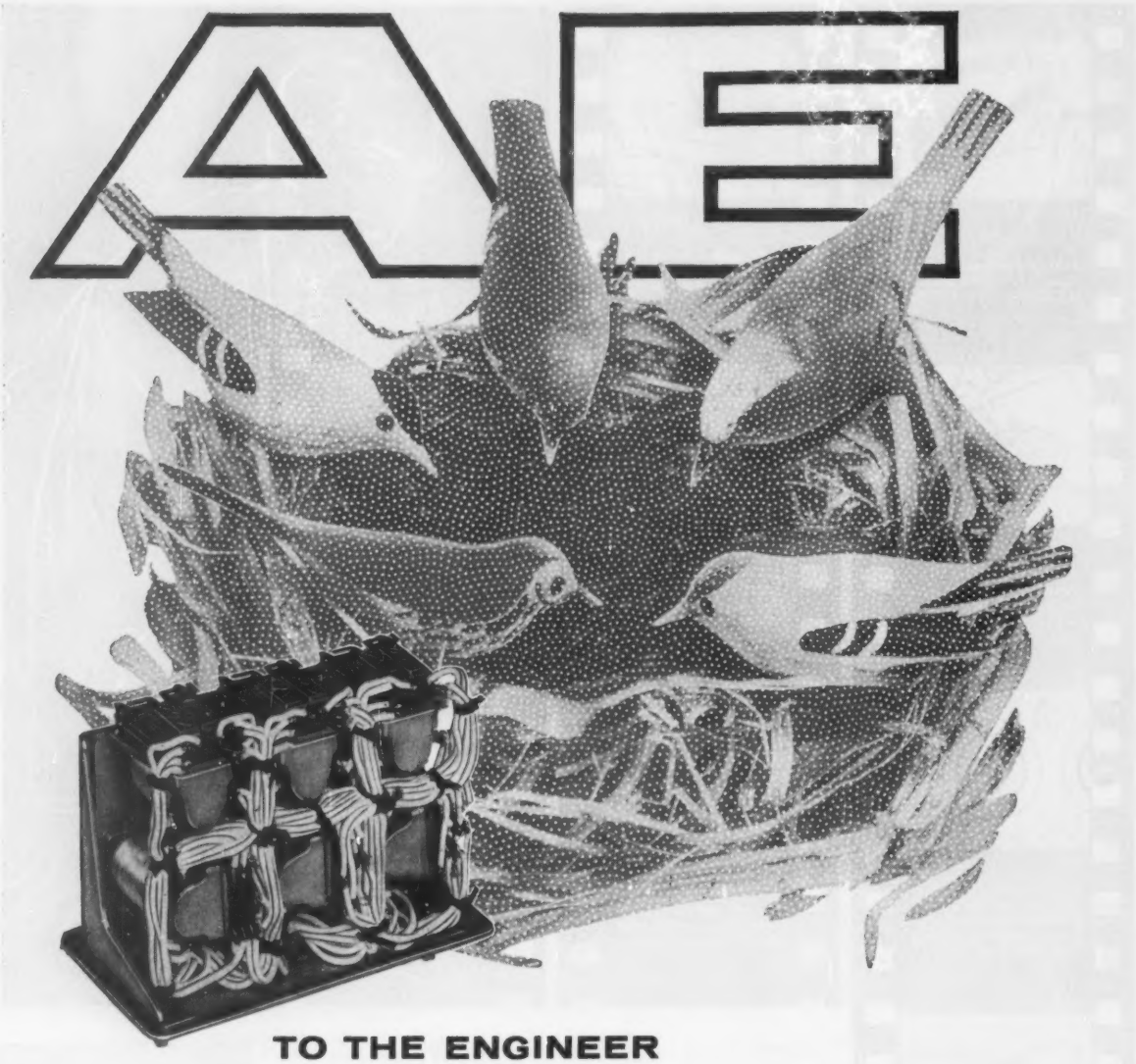
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UNION CARBIDE SILICONES



Circle 443 on Page 19




## TO THE ENGINEER

# who thinks "birds' nests" are for the birds...

Upset over the fancy wiring your control package demands? Relax! AE can turn a bird's nest into a thing of beauty *and* high reliability.

The reason is simple: we've had years of experience wiring complex dial telephone switchboards, to say nothing of little black boxes. And we have the techniques down so tidy and pat that our assembly and prewiring costs are more than likely lower than yours.

**As a beautiful example, take a look at the compact relay complex illustrated. This custom job is designed to do switching tricks over and over again without failure. A significant part of its dependability is structural rigidity.**

AE engineers are also gifted in solving the most complex switching circuits in the simplest and most inexpensive way. Chances are they can save you some headaches.

If you have a control problem, we'd like to hear about it. Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. And while you're at it, ask for Catalog 4083-A covering *AE Enclosures for Relays, Switches and Control Systems.*

**AE CAN DO**



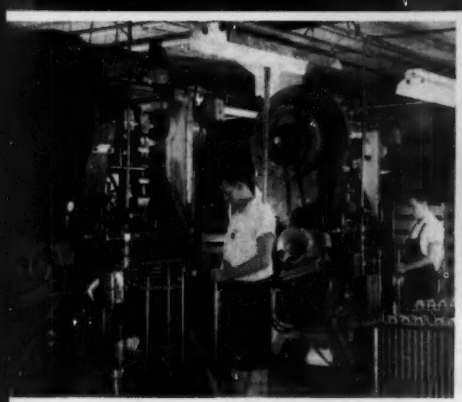
**AUTOMATIC ELECTRIC**

Subsidiary of

**GENERAL TELEPHONE & ELECTRONICS**

GENERAL SYSTEM

*Here's how the most highly automated production line in the plant makes production worthwhile.*



Line of Wichita-equipped Chicago Presses

# Air conditioning production at Friedrich pays off with Wichita equipped presses

Heat transfer parts are shown being turned out on Wichita equipped Perkins Presses at the rate of 120 strokes a minute in regular production (see small photo above.) The stock is automatically loaded, fed, flared and cut off. The Wichita Clutch makes the operation efficient and safe . . . with easy maintenance. George Spangler, Friedrich Refrigerators, Inc. production head, calls it the backbone of the airconditioning production.

The wide bed piercing and notching presses, shown in the main photograph, turn out a number of refrigeration parts up to 12 feet long. The Wichita Clutch is located at the left side of the presses with the flywheel. Friedrich especially likes the safety factor built into the Wichita Clutch. If the air system in the plant fails, the press stops automatically. The Wichita Clutch Brake combination makes it possible to stop the ram at any stage of its movement.

*A Wichita Engineer will be glad to work with your engineering and sales department to help you with any clutching or braking problem.*

WICHITA Clutch COMPANY, INC.

***Contact your nearest Wichita Engineer today!***

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# Veeder-Root READOUT Bulletin

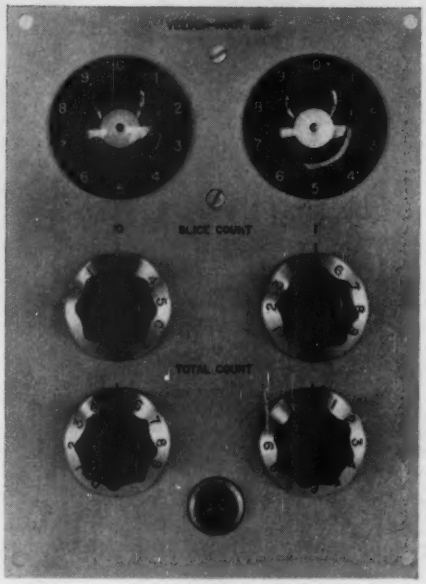
## New Electronic Counters provide simplified operation, automatic control for Original Equipment

Veeder-Root Electronic Predetermining Counters are now being used to improve machine efficiency by providing varying degrees of automatic control as original equipment.

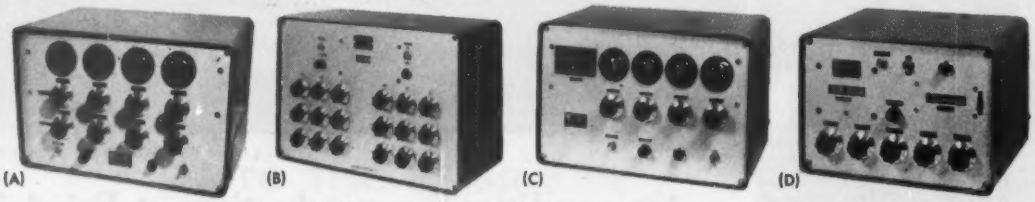
These new electronic counters count electrical impulses. This makes them extremely versatile — and suited to design innovation — because these pulses can be supplied by photoheads, snap-action switches, mechanical contactors, impact and proximity switches, and the like. Photohead actuation alone has almost limitless application potential, and is ideal for high velocity, non-contact counting at any stage of a machine's operation.

The predetermining action — which actuates machine controls, signals, etc., — can run the extreme from a single stop motion, with only one bank of selector knobs all the way to multiple banks which are used to set up a series of stop motions, usually sequentially. There is no theoretical limit on the number of banks (or sequential stops) that can be provided. Counting speeds are available up to 5000 counts per second, and even higher in special applications. Instantaneous reset and automatic recycling are also valuable features.

Some of the many possible counter variations are shown below. Both the 1804 Series, Electronic, and 1601 Series, Electric, Counters are providing this type of control as original equipment on a variety of machines, from bacon slicers to plastic film extruding machines. Design and engineering assistance is available to help achieve maximum operating efficiency for your equipment.

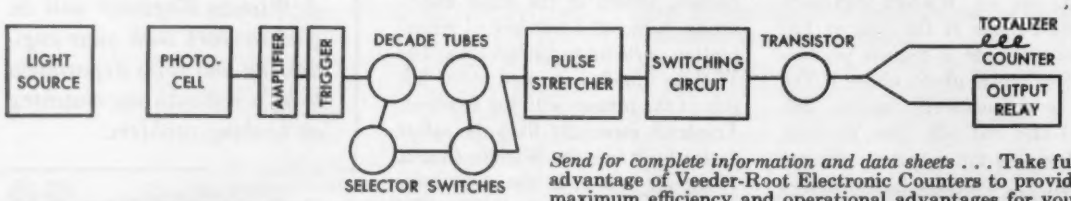



This is a panel mounted Series 1804 Predetermining Counter designed to control operation of a bacon slicing machine. Top bank of knobs is preset to number of slices in each package, other set controls total number of units or packages.




These are a few of the variations in predetermining control available with the Veeder-Root Series 1601 Electric and 1804 Electronic Counters. **(A)** For measuring film footage; when number on top set of dials is reached machine is slowed down, then stops when lower number is reached. **(B)** Series 1601 Counter, designed for sequential control based on six preset quantities. **(C)** A four figure counter incorporating a batch totalizer. **(D)** Series 1601 Counter with five figures, one set of preset numbers and a totalizer for counting cycles or batches.

### Simplified Schematic of the Veeder-Root Series 1804 Electronic Counter




Veeder-Root Electronic Counters are designed to your specific requirements. These are some of the many operations now being performed with this modern control method.

| | | |
|---|---|---|
| measuring | batching mixes | packaging rolls |
| bin loading | can counting | coil winding |
| pill packaging | bread slicing | labeling machines |
| tube cut off | cap counting | nail packaging |
| bag counting | flow measurement | conveyor control |
| tool control | predetermining revolutions | |

*Send for complete information and data sheets . . .* Take full advantage of Veeder-Root Electronic Counters to provide maximum efficiency and operational advantages for your equipment. Contact your nearest Veeder-Root Counting Engineer, or write direct.

**Veeder-Root**

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*"The Name that Counts"*

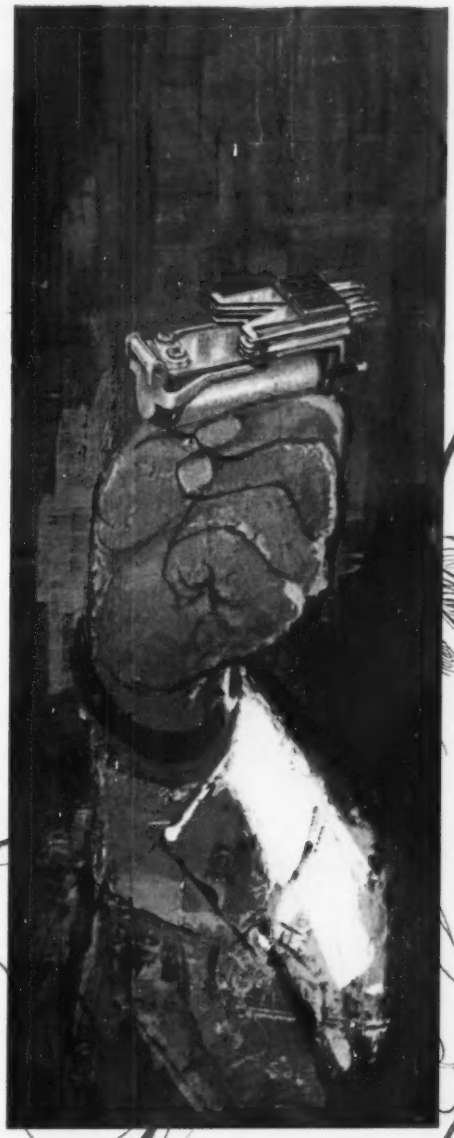
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Circle 447 on Page 19→



POTTER & BRUMFIELD *telephone type* RELAYS

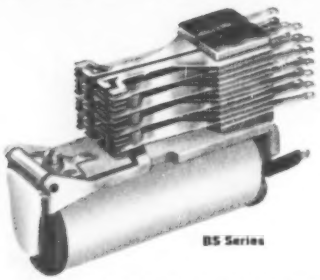


**POTTER & BRUMFIELD**

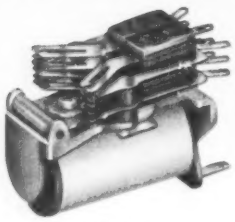
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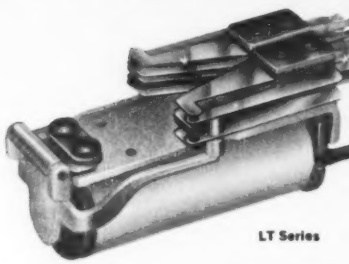
# POTTER & BRUMFIELD TELEPHO



BS Series



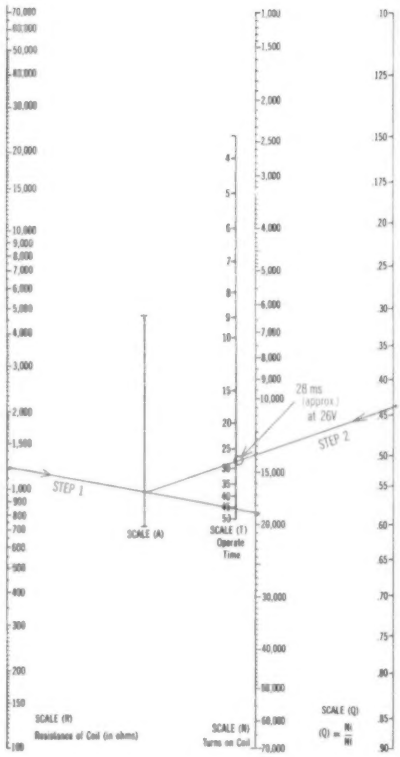
LS Series



LT Series

## BS SERIES NOMOGRAM

**This nomogram can be employed to determine relay requirements, as shown by the example below. A great many solutions to relay problems may be obtained by this method, but all answers will necessarily be approximations.**




### NOTES

Standard BS relays pick up pusher load at .012" gap.

Standard BS relays normally open contacts close at .008" gap.

Standardcontact pressure for BS and LS relays is 25 grams minimum.

Ni = Ampere-turns used as a design reference, not to be used as an actual operating value.

NI = Ampere-turns applied to the relay.

R = Relay coil resistance.

N = Turns on relay coil.

Fig. 1

| SERIES | COIL | | | TIME V |
|---|---|---|---|---|
| | VOLTAGE | POWER | RESISTANCE IN OHMS | OPERATE |
| BS | DC: to 220V<br>AC: to 230V 60 cycle | DC: 25MW/movable arm min. 8 watts max. @ +25°C<br>AC: 17.9VA | DC: 100,000 max.<br>(Breakdown 1,000 volts) | DC: 5 to 120 MS<br>AC: 10 to 25 MS |
| LS | DC: to 220V | 65MW/movable arm min.<br>5 watts max. @+25°C. | DC: 55,000 max.<br>(Breakdown 1,000 volts) | DC: 5 to 70 MS |
| LT | DC: to 220V | DC: 15MW/movable arm avail. 20 MW min. 8 watts max. @ +25°C | DC: 100,000 max.<br>(Breakdown 1,000 volts) | DC: 10 to 100 MS |
| TS | DC: to 200V<br>AC: to 230V 60 cycle | DC: 100MW/movable arm min. 3 watts max. @ +25°C.<br>AC: 4.5VA | DC: 22,000 max.<br>(Breakdown 1,000 volts) | DC: 5 to 40 MS<br>AC: 10 to 25 MS |
| GS | DC: to 220V<br>AC: to 230V 60 cycle | DC: 50MW/movable arm min. 6 watts max. @ +25°C<br>AC: 12.7VA | DC: 50,000 max.<br>(Breakdown 1,000 volts) | DC: 5 to 50 MS<br>AC: 10 to 25 MS |
| MH | DC: to 125V<br>AC: to 230V intermittent duty only | DC: 100MW/movable arm min. 4 watts max. @ +25°C<br>AC: 4.6VA | DC: 22,000 max.<br>(Breakdown 500 volts) | DC: 5 to 35 MS |
| KS | DC: to 125V max. | DC: 200MW/movable arm min. 3 watts max. @ +25°C | DC: 10,000 max.<br>(Breakdown 1,000 volts) | DC: 5 to 20 MS |

### PRESSURE CONVERSION CURVE

**BS Series**

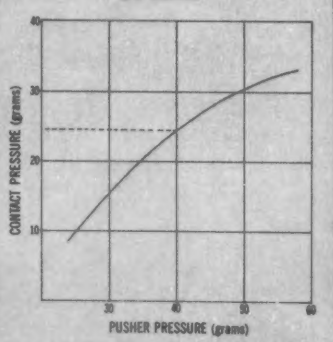



Fig. 2

### COIL TEMPERATURE RISE

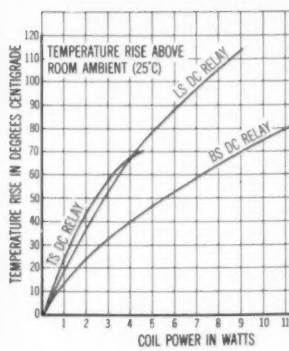



Fig. 3

**Example:** To select Coil, Determine Operate Time, and Coil Temperature Rise.

**Problem:** 26VDC nominal, 32VDC max., 18VDC min. } Power source

5 form C contact arrangement.

**Solution:**

1. First convert contact pressure to pusher pressure using Figure 2. Assume a contact pressure of 25 grams total per normally closed contact form. 1 form C @ 25 grams per contact form is 40 grams per contact form at the pusher. 5 × 40 = 200 grams total pusher load.

2. Next, to determine amp-turns required, use Figure 4. Standard load transfer (from contacts to armature) point for BS series relay is .012, hence, the Ni would be 180.

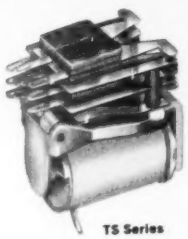
3. Knowing the value of Ni, the following calculations apply. Use a safety factor of 1.2 at the minimum operating voltage.

$$\frac{18\ V\ DC}{R} \times N \geq 1.2 \times 180 \geq 216$$

Where R is resistance of coil, N is turns of coil.
Substituting values from coil data of Figure 5, possible solutions would be:

# IONE TYPE RELAYS

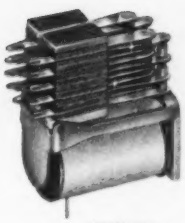




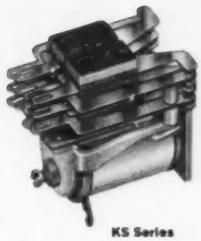
TS Series



GS Series



MH Series



KS Series

| IME VALUES | | CONTACTS | | | MECH-ANICAL LIFE (Cycles) | MOUNTING (standard) (approximate) | DIMENSIONS (approx. in inches) | WT. (approx.) (open) |
|---|---|---|---|---|---|---|---|---|
| ATE | RELEASE | MAXIMUM NUMBER OF SPRINGS | CONTACT MATERIAL | RATING (100,000 cycles) | | | Length x Width x Height | |
| MS | DC: 5 to 600 MS | DC: 28 (14/stack) | 1/16" dia. twin palladium, standard | 4 amps @ 115V 60 cycle resistive | 100 million min. | Two 8-32NC-2b tapped holes on ¾" centers | Min. 3⅜ x 1¼₆₄ x 1½ | 10 ozs. |
| MS | AC: 10 to 20 MS | AC: 24 (12/stack) | | DC: 4 amps 150 watts | | | Max. 3⅜ x 1¼₆₄ x 2½ | |
| MS | DC: 5 to 140 MS | DC: 24 (12/stack) | 1/16" dia. twin palladium | 4 amps @ 115V 60 cycle resistive | 100 million min. | Two 6-32 tapped holes on ¾" centers | Min. 2⅛ x 1⅛ x 1⅝₂ | 3¼ ozs. |
| | | | | DC: 4 amps 150 watts | | | Max. 2⅛ x 1⅛ x 1³⁵⁄₆₄ | |
| 0 MS | DC: 10 to 400 MS | DC: 24 (12/stack) | 5/64" dia. palladium | 3 amps @ 115V 60 cycle resistive load. | 50 million min. | Two 8-32 tapped holes on ¾" O.C. | Min. 4⅛ x 1⅝₂ x 1¹⁵⁄₁₆ | 12 ozs. |
| | | | | DC: 3 amps 135 watts | | | Max. 4⅛ x 1½ x 2¹⁄₁₆ | |
| MS | DC: 5 to 50 MS | DC: 20 (10/stack) | 5/64" dia. palladium | 3 amps @ 115V 60 cycle resistive. | 100 million min. | Four 3-48 tapped holes ⅝" X ⅜" O.C. | Min. 1⅝₁₆ x 1⅝₂ x 1⅝₁₆ | 2¼ ozs. |
| MS | AC: 10 to 20 MS | AC: 6/stack (4 poles max.) | | DC: 3 amps 135 watts | | | Max. 1⅝₁₆ x 1⅝₂ x 1¹³⁄₁₆ | |
| MS | DC: 5 to 100 MS | DC: 20 (10/stack) | 5/64" dia. palladium | 3 amps @ 115V 60 cycle resistive. | 50 million min. | Two 8-32 tapped holes on ½" centers | Min. 2¹⁷⁄₃₂ x 1⅝₂ x 1³³⁄₆₄ | 10 ozs. |
| MS | AC: 10 to 20 MS | AC: 18 (9/stack) | | DC: 3 amps 135 watts | | | Max. 2¹⁷⁄₃₂ x 1½ x 2⅛₂ | |
| MS | DC: 5 to 25 MS | DC: 18 (9/stack) max. AC: 3/stack (2 poles max.) | ⅛" dia. gold-flashed silver | 3 amps @ 115V 60 cycle resistive load. | 10 million min. | Four 3-48 tapped holes ⅝" X ⅜" O.C. | Min. 1²¹⁄₃₂ x ²⁵⁄₆₄ x 1⅝₂ | 2 ozs. |
| | | | | | | | Max. 1²¹⁄₃₂ x ²⁵⁄₆₄ x 1³⁵⁄₆₄ | |
| TS | DC: 2 to 8 MS | DC: 12 (6/stack) | 5/64" dia. palladium | 3 amps @ 115V 60 cycle resistive load. DC: 3 amps 135 watts | One million min. | Two 5-40 tapped holes on ⅝" X 7/16" centers | Min. 1³⁵⁄₆₄ x 1⁵⁄₆₄ x 1⅝₂ | 1⅝ ozs. |
| | | | | | | | Max. 1³⁵⁄₆₄ x 1½ x 1¹³⁄₆₄ | |

| SPECIAL FEATURES | | | | | | | |
|---|---|---|---|---|---|---|---|
| BS | LS | TS | GS | LT | MH | KS | |
| X | X | | X | X | | | Quarter-inch-creepage insulation. (1500 volts) |
| X | X | X | X | X | X | X | Fixed or adjustable residual |
| X | X | X | X | X | X | X | Humidity and anti-fungus treatment. |
| X | X | X | X | X | X | X | Protective enclosures |
| X | X | X | X | X | X | X | Hermetically sealed |
| X | X | X | X | X | X | X | Contrifically impregnated coil (open relays) |
| X | X | X | X | X | X | X | Impregnated pile-up (open relays) |
| X | X | X | X | X | | | Plug-in mounting |
| X | X | X | X | X | X | | Time delay |
| X | X | X | X | X | X | X | Taper tabs |
| | X | X | | | X | X | Printed circuit tabs |
| X | X | X | X | X | X | X | Other contact materials available |
| X | X | X | | | X | | Single o.r bifurcated contact arms avail. |
| X | X | X | X | X | X | X | Special gold alloy contacts avail. |
| | X | X | | | X | X | Other mountings avail. |
| X | X | X | X | X | X | X | Octal plugs-solder header or miniature Plug-in |
| | | | | | X | | Sealed—available with separately sealed coils |
| X | X | X | X | X | X | X | Sealed AC relays avail. w/built-in rectifier. |

**Note:** Standard stack insulation for all telephone relays consists of laminated phenolic spacers for temperatures up to +85°C. Special insulation for +125°C operation is available.

**Note:** Standard coil insulation for temperatures up to +85°C. Special insulation material available for operation to +125°C.

RISE




## BS SERIES PULL CURVE

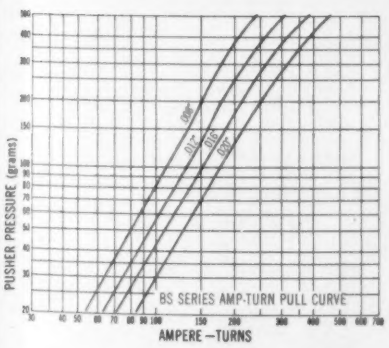



Fig. 4

## COIL DATA

**Turns and Resistance**

| Wire Size | BS | | LS | | TS | |
|---|---|---|---|---|---|---|
| | N | R | N | R | N | R |
| 29 | 5,100 | 80 | 1,750 | 20 | 1,260 | 14.3 |
| 30 | 6,400 | 127 | 2,220 | 31 | 1,600 | 23 |
| 31 | 7,800 | 200 | 2,800 | 50 | 2,000 | 37 |
| 32 | 10,000 | 310 | 3,500 | 80 | 2,550 | 60 |
| 33 | 12,600 | 480 | 4,400 | 125 | 3,300 | 94 |
| 34 | 15,000 | 750 | 5,500 | 200 | 4,100 | 150 |
| 35 | 18,700 | 1,200 | 7,000 | 320 | 5,000 | 240 |
| 36 | 23,500 | 1,820 | 8,800 | 520 | 6,500 | 400 |
| 37 | 29,000 | 2,900 | 11,000 | 820 | 8,100 | 610 |
| 38 | 36,000 | 4,400 | 14,000 | 1,350 | 10,200 | 1,000 |
| 39 | 44,000 | 7,000 | 17,500 | 2,150 | 13,000 | 1,600 |
| 40 | 55,000 | 11,000 | 22,200 | 3,400 | 16,300 | 2,600 |
| 41 | 68,000 | 17,000 | 28,000 | 5,400 | 20,500 | 4,100 |
| 42 | 85,000 | 26,500 | 35,000 | 8,600 | 26,000 | 6,600 |
| 43 | 100,500 | 41,000 | 44,000 | 13,700 | 35,000 | 10,300 |
| 44 | 130,000 | 65,000 | 56,000 | 21,800 | 42,000 | 17,000 |

Fig. 5

## ENCLOSURES

| Type | Maximum Dimensions Length X Width X Height | Fits Relays |
|---|---|---|
| | **SEALED** | |
| N | 4.375 X 2.375 X 3¼ | BS-LT |
| G | 2³¹⁄₃₂ X 2⁹⁄₃₂ X 3³⁷⁄₆₄ | GS |
| M | 1¹¹⁄₁₆ X 1⁵⁄₃₂ X 2⁷⁄₃₂ | MH |
| R | 1.421 X .890 X 1²⁵⁄₃₂ | MH |
| | **SEALED OR DUST COVER** | |
| W | 1²⁵⁄₃₂ X 1¹³⁄₁₆ X 2⅛ | LS |
| D | 1²⁵⁄₃₂ X 1¹³⁄₁₆ X 2¹¹⁄₁₆ | TS |
| K | 1¹³⁄₃₂ X 1⅜ X 2⅛ | TS |
| K (Spl.) | 1¹³⁄₃₂ X 1⅜ X 2⅛ | LS |
| | **DUST COVERS** | |
| BS Special | 4⁷⁄₁₆ X 1⁷⁄₃₂ X 2³³⁄₆₄ | BS |
| LT Special | 4⅛ X 2 X 2⅛ | LT |
| P (clear) | 1¹³⁄₃₂ X 1³³⁄₃₂ X 2⁵⁄₁₆ | MH |

Fig. 6

$\frac{18}{750}$ X 15,000 = 360 amp-turns (Coil 1)

$\frac{18}{1200}$ X 18,700 = 280 amp-turns (Coil 2)

$\frac{18}{1820}$ X 23,500 = 232 amp-turns (Coil 3)

Results indicate best choice to be Coil 2. Coil 3 might result in marginal operation at minimum voltage.

4. After coil is selected, Q can be calculated and the operate time determined from the nomogram, Figure 1.

$$Q = \frac{Ni}{NI}$$

$$Q \text{ @ } 26V = \frac{180}{\frac{26}{1200} \times 18{,}700} = \frac{180}{405} = .44$$

**Step 1:** Draw a line from SCALE R to SCALE N, marking the intersection on SCALE A.

**Step 2:** Draw a line from this point on SCALE A to SCALE Q. The intersection on SCALE T gives the operate time.

Using Coil 2, the operate time for this configuration at nominal voltage would be approximately 28 milliseconds.

5. Coil temperature rise for Coil 2 in this example is determined from Figure 3

$$\frac{E^2}{R} = W = \frac{(26)^2}{1200} = .56 \text{ watts}$$

Hence, coil temperature rise is 8°C. at 25°C.




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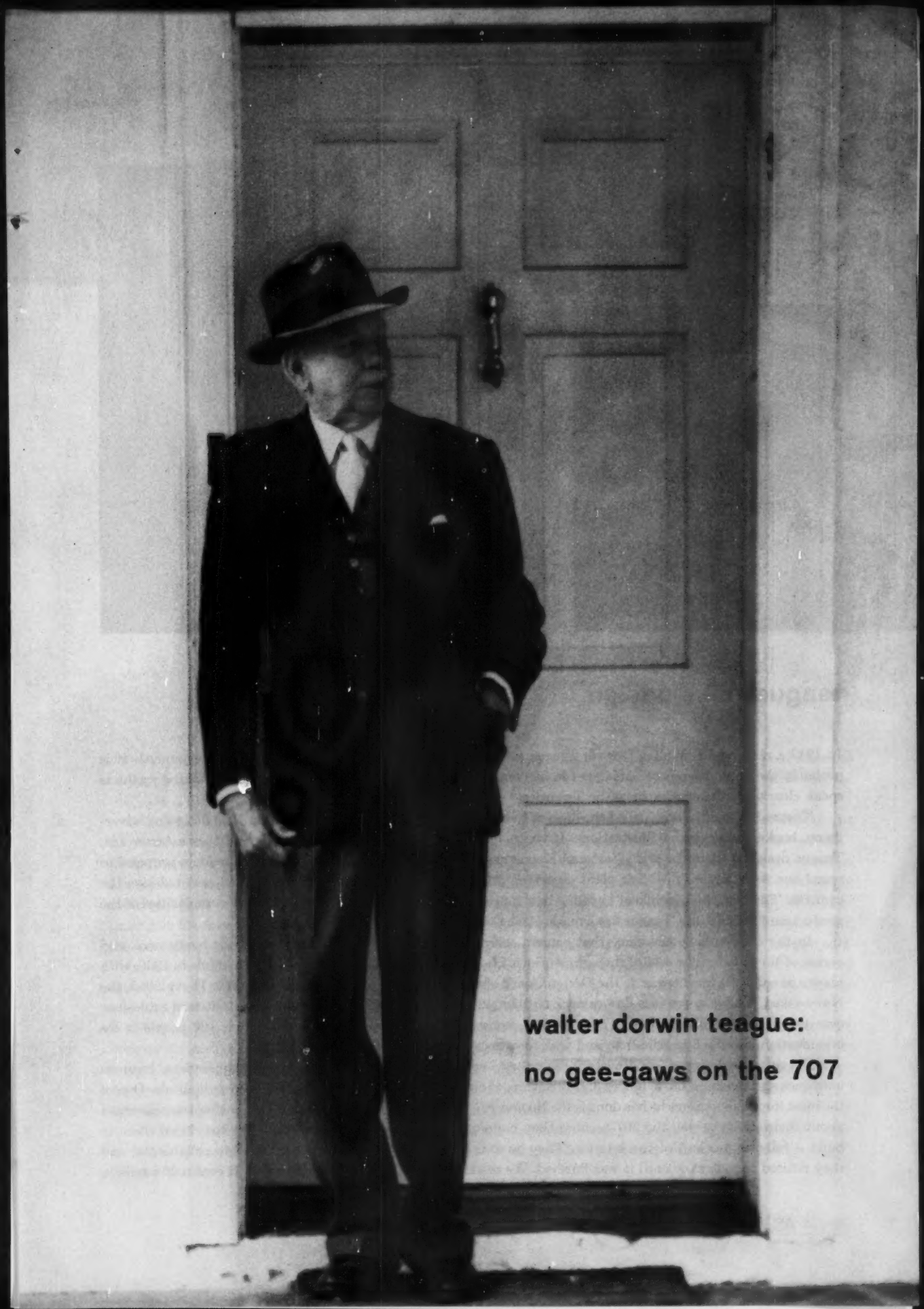
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**walter dorwin teague:**

**no gee-gaws on the 707**





## teague talks design

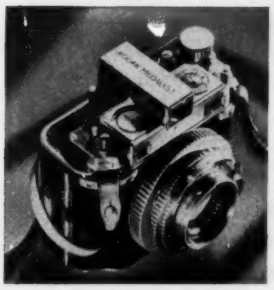
In 1942 a man named Walter Dorwin Teague published "You Can't Ignore Murder," a mystery novel. It is probably the only attempt at bafflement in his long history, because Walter Teague has been making products speak clearly for themselves since the Twenties.

Teague has rightly been called the dean of industrial design. He began as an artist in 1908 designing advertising, books and magazine illustrations. If you're old enough to remember Locomobile and Pierce Arrow ads, Teague designed them. In 1927, Eastman Kodak asked him to redesign their cameras. He made a proposal to spend one week a month in their plant observing production problems and techniques, and *then* redesign the cameras. That simple principle of knowing how a product is made, of understanding all the complexities of the production line, is still a Teague trademark. And Eastman Kodak is still a Teague client.

In the thirty-plus years since that camera assignment, Teague has explored just about every nook and corner of the wonderful world of three dimensions. He designed the classic Marmon 16 automobile in 1930, with his son as collaborator; he was on the Design Board of the 1939 World's Fair. When World War II exploded, the Navy asked Teague to perform design work on their 16-inch guns in order to eliminate possibilities of explosions caused by loading malfunctions. Today he still works for the Bureau of Ordnance. He has 120 people in his organization, a branch in San Juan and task forces scattered across the United States

Teague has designed service stations, railway equipment, plane interiors, heating appliances, business machines and machine tools, offices and furniture, showrooms and department stores, even periodicals. One of the most impressive things he has done is the Boeing 707 jet interiors. Mr. Teague recalls: "Boeing was concerned about their ability to sell the 707 because they hadn't made civilian planes for years. We convinced them to build a full-size mockup of the interior. They gave us *carte blanche* with body engineers to collaborate, and they refused to look at it until it was finished. We made it complete to the tiniest detail. It cost half a million







dollars and helped in selling most of the huge fleet now in the air. Our staff is responsible for the final interiors of the planes purchased by eighteen or more airlines, and for the interiors of executive planes purchased by the United States Government."

Whether mammoth jet airliners or chairs, a product is designed to five principles that are the *modus operandi* of the Teague organization. "First of all, the redesigned product has to work better for our efforts," Teague says. "It should be more convenient to use, more humanized. It must make honest use of the material it's made of, and it's got to be capable of being efficiently manufactured at the proper price. We assiduously avoid gee-gaws or extraneous ornamentation that adds nothing but price to the product. Finally, the design must give the user an emotional pleasure or gratification each time it is used." Selection of the right material for the job is important to each of Teague's requirements. "We endorse no material over another," Teague says. "We first look for the material that is best in keeping with the product's desired personality. Strength and durability are highly important in material selection. Then we make sure our client's tooling can handle the material we have in mind. Above all, it takes the right material to sell the product to the consumer."

Teague has used practically all materials known to man and it is no accident that a great many of his designs use steel in one way or another. "The wonderful thing about steel is its versatility," says Teague. "Its many alloys, old and new, give it adaptability that other materials don't have. Its strength, both in tension and compression, qualifies it for literally thousands of uses. And stainless steel is another reason why steel is a modern metal because it gives so many designs their contemporary look."

The moral is this: steel is an ageless metal, as much at home in the Boeing 707 and today's elegant tableware as it was in medieval days. Its enduring modernity will always be recognized and used by designers like Walter Dorwin Teague.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

USS TRADEMARK United States Steel

# designing with stainless steel

The ideal design has been described as one in which the properties of the material are fully utilized in the finished product. This ideal is difficult to achieve, and no group of materials comes as close to permitting this ideal as stainless steel.

To put it differently, no other material combines so many outstanding properties as the stainless steels. Stainless steels have high tensile strength. All are hardened and made even stronger by cold working. As a family they offer superb resistance to the corrosive effects of an enormous variety of reagents. They have unusual resistance to high temperature oxidation, and are distinguished by relatively low heat conductivity. And on top of their remarkable physical properties, stainless steel's lustrous appearance and sales appeal scarely need mention.

*There are over 30 types of stainless steel today.*

The history of stainless steel's use is marked by designers who turned a healthy profit with a quality material but mainly with sound ideas. They're the men who used stainless for its strength and sales appeal in toaster covers, its appearance and machinability in wrist watches, its structural properties and cleanability for truck trailer parts. Stainless steel cuts weight and adds years to the life of architectural panels; its corrosion resistance and smooth, pocket-free surface have made it the standard of the dairy industry. There are literally thousands of applications of stainless steel in which designers have utilized one, two or more of the remarkable properties of stainless steel.

*By reflecting the color of its surroundings, stainless steel contributes to harmonious design.*

*Types 302, 410 and 430 make up 75% of stainless steel's uses.*

Good design is honest design, whether it uses stainless steel or other materials. Yet the fact remains that there is no other commercial material quite as versatile as stainless steel. The applications shown on these pages are just a few of the hundreds of uses to which stainless is put every day. To learn more about stainless steel and its design properties, call our nearest sales office or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

*Successful designers don't substitute stainless steel sections for sections of other materials. They design to stainless' unique properties.*

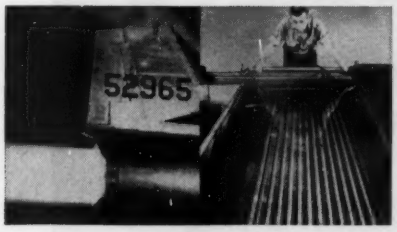
*Good design doesn't stop with function and sales appeal. It must also be capable of economical manufacture. As a comprehensive guide, send for the free book described at the right.*

**Stainless steels represent but a few of the thousands of grades of steel in existence today. United States Steel makes a complete line of stainless steels as well as alloy, high strength and carbon steels. Bring your design problems to us.**

*USS is a registered trademark*

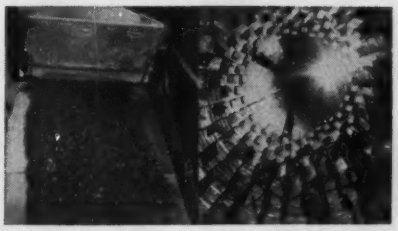
USS United States Steel

**No Material comes close to stainless steel's versatility. By way of illustration, here are a few "opposites" that prove our point.**



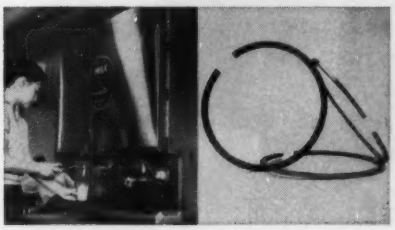

**HOT.** Temperatures in a jet afterburner reach 1400°F.

**COLD.** Stainless heat exchanger operates at temperatures as low as —443°F.



**WET.** Combination of moisture and coal would corrode nearly anything but stainless.

**DRY.** Rotary dryer is used to dry pharmaceutical ingredients.



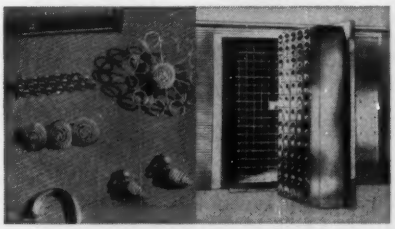
**CLEAN.** Milk dispensers of stainless steel prevent contamination.

**DIRTY.** Stainless piston rings resist high temperature corrosion.



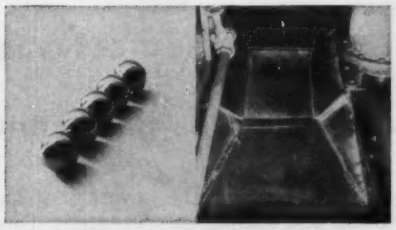
**INSIDE.** Chemical tanker needs simple wash-out for cleaning.

**OUTSIDE.** Stainless automobile trim stays bright and good-looking.



**LIGHT.** Stainless steel jewelry has a light, graceful appearance.

**HEAVY.** Strength and hardness of stainless combine to make safe doors safe.



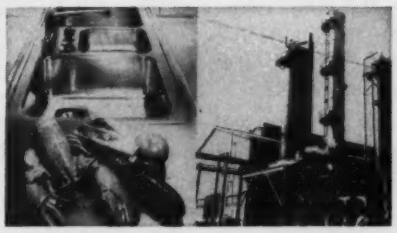
**ROLL.** Stainless ball bearings take a lot of punishment.

**SLIDE.** Abrasion resistance of stainless steel makes chutes last longer.



**FORM.** Stainless steel wrist watch keeps time and beauty.

**FUNCTION.** Stainless steel muffler defies heat with silence.



**WATER.** Stainless sinks stay bright and beautiful.

**FIRE.** Stainless steel shingles inside cat crackers are red hot.

This mark tells you a product is made of modern, dependable Steel.

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**Stainless steel's** properties require close control over processing and in some cases, special fabricating techniques. Its cold working and joining characteristics are of special interest to the designer and will often influence final design. For complete coverage of the subject, send for your free copy of our newly revised manual:

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Title_____

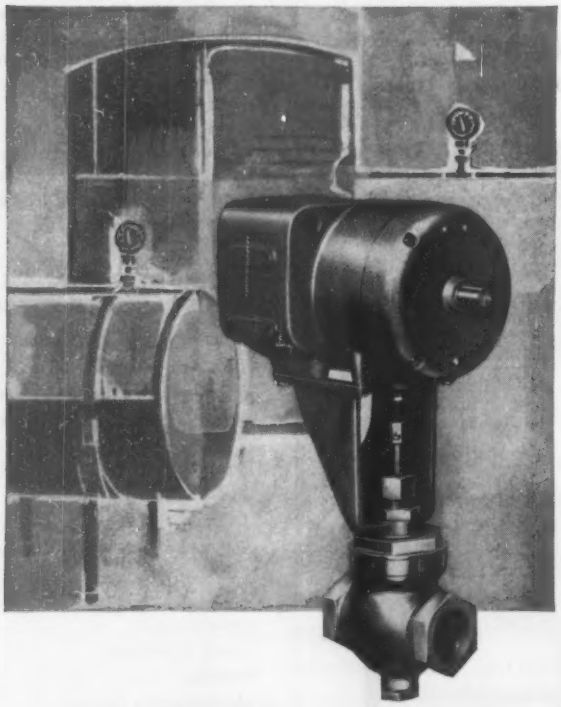
Company_____

Address_____

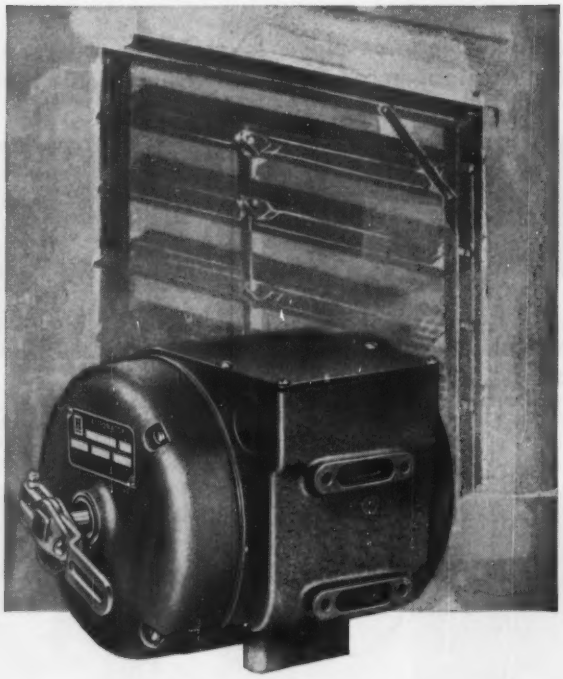
City_____

Zone____ State_____

OPERATE ANY SLIP STEM OR ROTARY STEM VALVE



OPERATE ALL INDUSTRIAL TYPE DAMPERS



# more torque! more precise positioning for industrial valve and damper applications *New Honeywell*

## *ACTIONATOR* heavy-duty electrical control motors*

Use these compact, powerful new industrial motors in dairies, breweries, water works—for ovens and cooling towers—wherever highly accurate modulating or two-position control is required.

Some models operate vertical-acting stem valves having lifts of from ½ to 1½ inches. The double-ended shaft can also simultaneously operate rotary stem valves, butterfly valves and other devices through suitable linkages. Other models operate rotary-shaft type valves, dampers, louvers and other final control elements.

ACTIONATOR control motors are available with two-position, floating or proportional control, and with a variety of speeds from 7.4 to 120 seconds full-stroke operation. Torque ratings range to 200 inch/lbs.

Additional features include built-in linkage and strain relief, a mounting yoke and enclosed terminals with gasketed housing to meet JIC specifications. Also available are models that include cam-operated internally mounted switches for a variety of sequencing switching purposes.

For complete information, call your local Honeywell office. Or write Minneapolis-Honeywell, Dept. MD-9-54, Minneapolis 8, Minnesota. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

**Trademark*

75th YEAR — PIONEERING THE FUTURE

**Honeywell**

First in Control

SINCE 1885

*See us in Sweet's 1960 Product Design File, Section 5b-Min.*

# Aetna BEARINGS

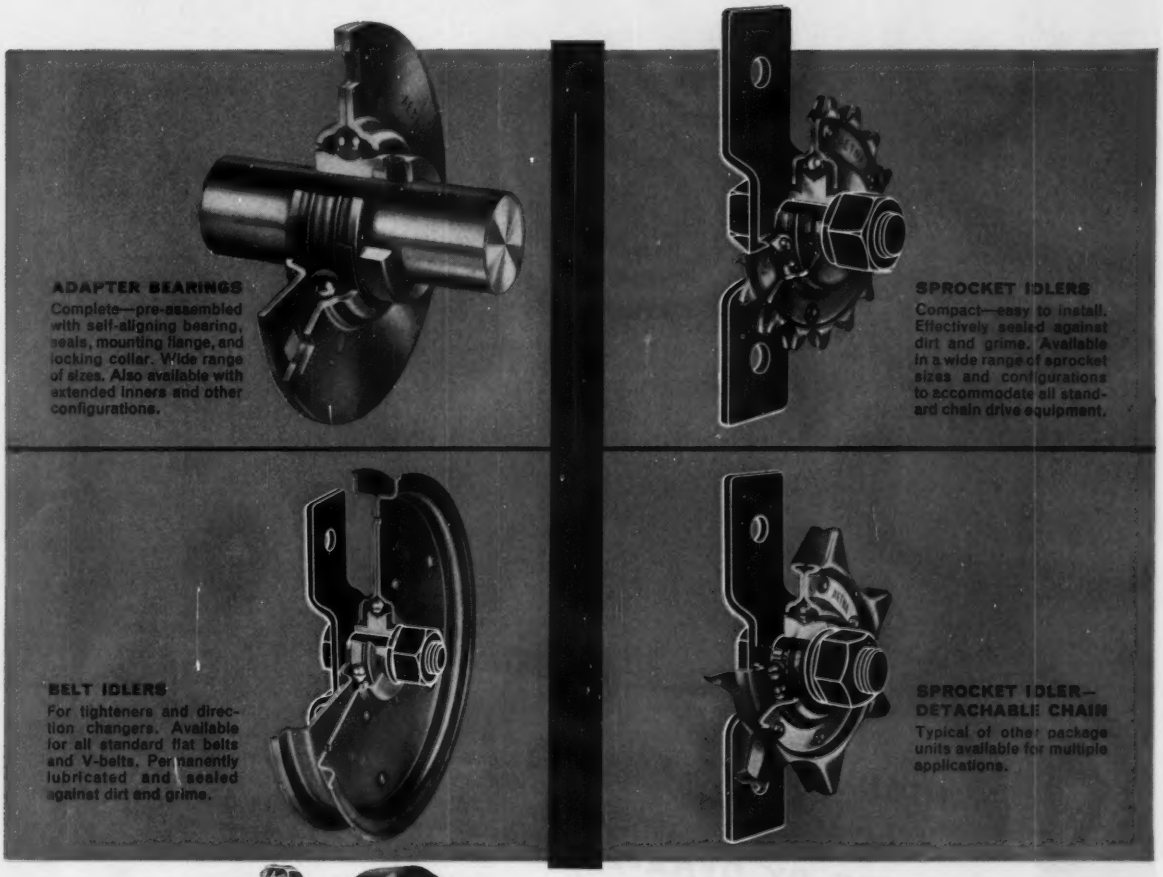
## *Aetna Packaged Bearing Units*

## REDUCE COSTS...

## STEP UP PRODUCTION

**Low-cost Aetna packaged bearing units simplify modern assembly line production. Designed as complete, integral, prelubricated units, these bearings greatly reduce over-all assembly costs and assembly time, and minimize stock handling. Individual units are simple in design, incorporating a single row of radial ball bearings with extra large lubricant capacity and a highly efficient seal. For all light-duty, medium speed applications, they assure dependable product performance free from troublesome servicing.**

**For complete information, call your Aetna representative listed in your telephone directory, or write for Prelubricated Bearing Catalog AG-59.**

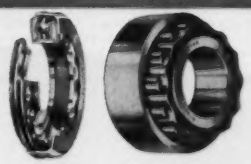


**ADAPTER BEARINGS**
Complete—pre-assembled with self-aligning bearing, seals, mounting flange, and locking collar. Wide range of sizes. Also available with extended inners and other configurations.

**SPROCKET IDLERS**
Compact—easy to install. Effectively sealed against dirt and grime. Available in a wide range of sprocket sizes and configurations to accommodate all standard chain drive equipment.

**BELT IDLERS**
For tighteners and direction changers. Available for all standard flat belts and V-belts. Permanently lubricated and sealed against dirt and grime.

**SPROCKET IDLER—DETACHABLE CHAIN**
Typical of other package units available for multiple applications.



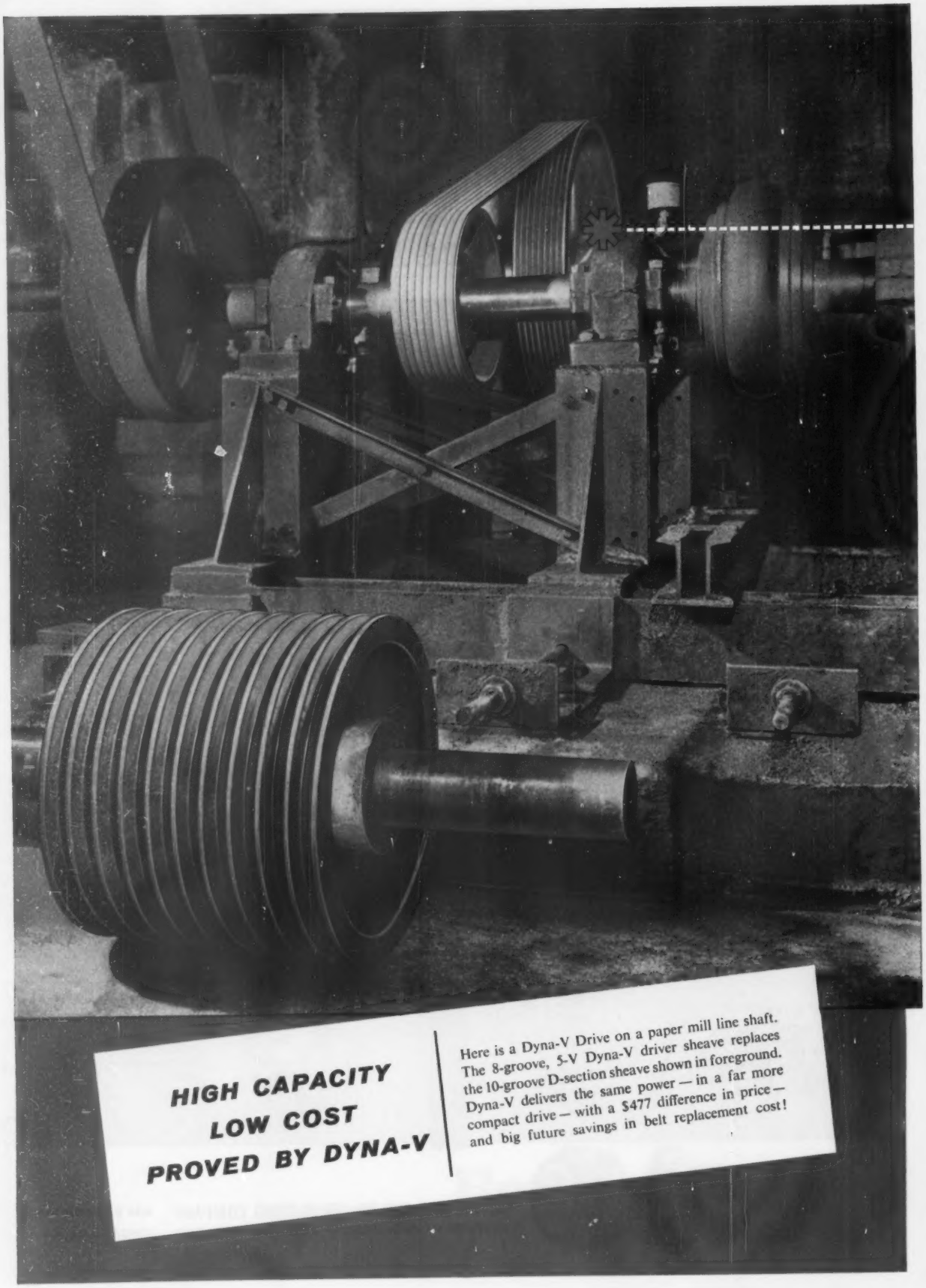
**AETNA BALL AND ROLLER BEARING COMPANY**
DIVISION OF PARKERSBURG-AETNA CORPORATION

4600 SCHUBERT AVE.
CHICAGO 39, ILL.

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916




*Circle 449 on Page 19*

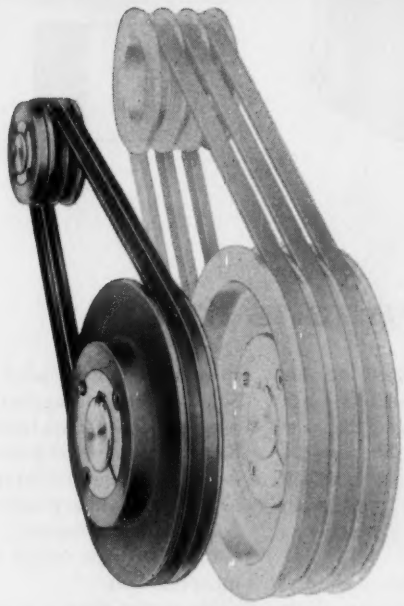


**HIGH CAPACITY**
**LOW COST**
**PROVED BY DYNA-V**

Here is a Dyna-V Drive on a paper mill line shaft. The 8-groove, 5-V Dyna-V driver sheave replaces the 10-groove D-section sheave shown in foreground. Dyna-V delivers the same power — in a far more compact drive — with a $477 difference in price — and big future savings in belt replacement cost!

# Dyna V

## THE NEW MONEY-SAVING IDEA IN V-BELT DRIVES!



Dyna-V compared with big-groove drive for same hp. Dyna-V is capable of handling 3 times as much hp in the same space! Dyna-V Drives are available for capacities from 1 to 1500 hp.

The day of big-groove sheaves and belts is passing. The new idea of compact V-belt drives—Dyna-V—introduced by Dodge just a few short months ago, is taking the country by storm. Thousands of Dyna-V Drives are at work in industry everywhere, carrying their loads easily, dependably, and proving their ability to *deliver more horsepower per dollar!*

Dyna-V utilizes the full performance possibilities of today's great synthetic fibers for belts—and modern metals for sheaves. Narrow belt top widths team up with narrow sheave grooves to create Dyna-V compactness. Narrow grooves reduce face width—save weight. Costs are lowered. Smaller diameter sheaves and shorter center distances multiply savings. With Dyna-V you cut costs on most initial installations and economize on belt replacements as well. In medium and high hp ranges these savings can be as much as 30%.

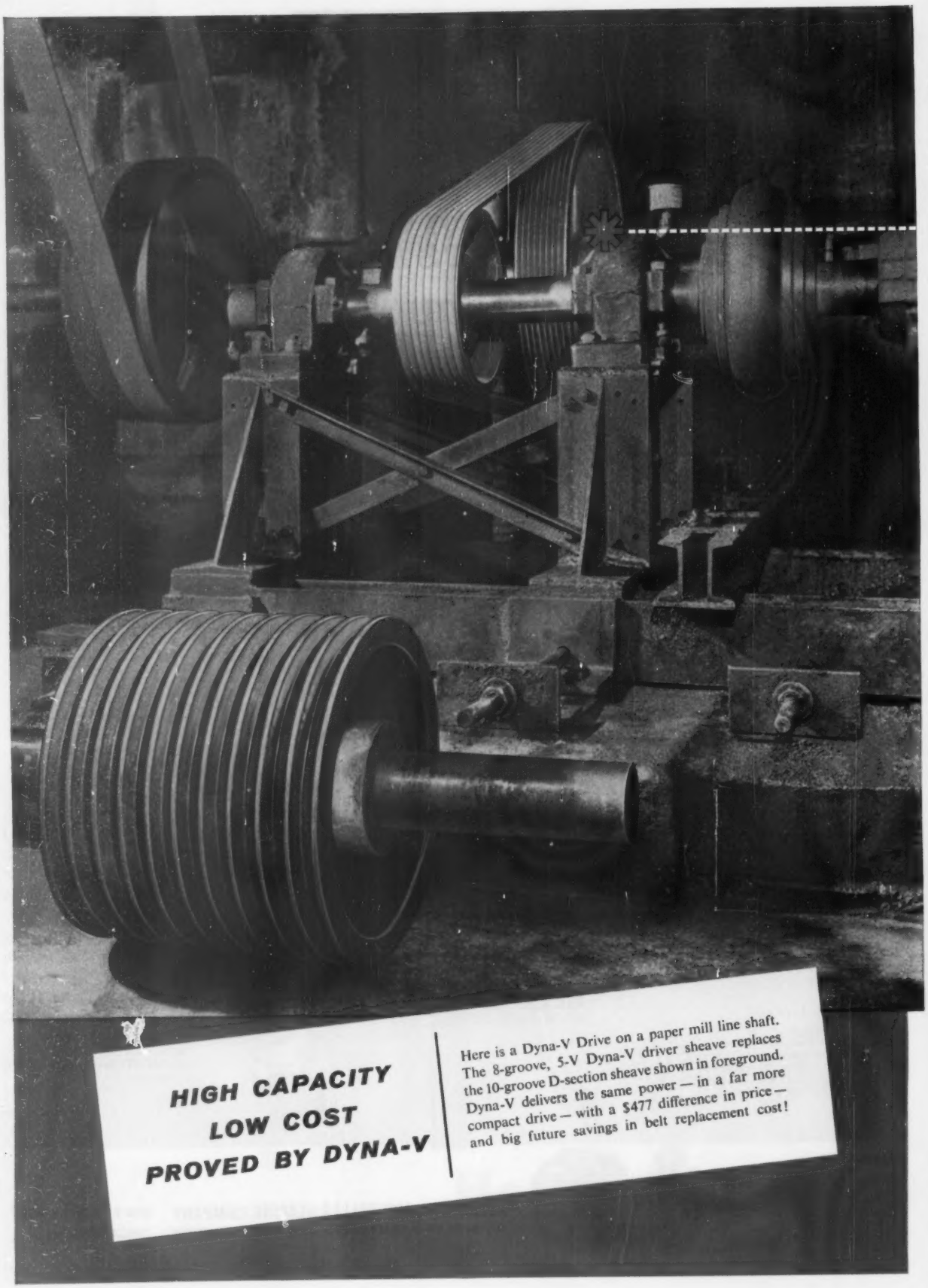
Dyna-V Sheaves decrease shaft overhang—increase bearing life. And Dyna-V Belts possess all premium qualities. Conditions requiring oil, heat, moisture resistance or static conductivity are met by Dyna-V's one grade—the finest. Ask your local Dodge Distributor. Or write us for Dyna-V Bulletin.



**CALL THE TRANSMISSIONEER** — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery".

**DODGE**
*of Mishawaka, Ind.*

**DODGE MANUFACTURING CORPORATION, 3300 UNION STREET, MISHAWAKA, INDIANA**

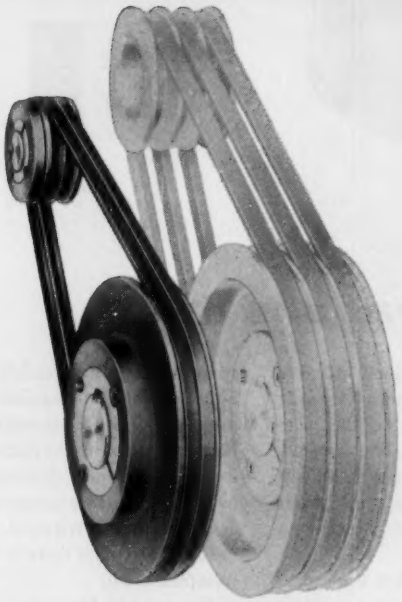


**HIGH CAPACITY**
**LOW COST**
**PROVED BY DYNA-V**

Here is a Dyna-V Drive on a paper mill line shaft. The 8-groove, 5-V Dyna-V driver sheave replaces the 10-groove D-section sheave shown in foreground. Dyna-V delivers the same power — in a far more compact drive — with a $477 difference in price — and big future savings in belt replacement cost!

# Dyna V

## THE NEW MONEY-SAVING IDEA IN V-BELT DRIVES!



Dyna-V compared with big-groove drive for same hp. Dyna-V is capable of handling 3 times as much hp in the same space! Dyna-V Drives are available for capacities from 1 to 1500 hp.

The day of big-groove sheaves and belts is passing. The new idea of compact V-belt drives—Dyna-V—introduced by Dodge just a few short months ago, is taking the country by storm. Thousands of Dyna-V Drives are at work in industry everywhere, carrying their loads easily, dependably, and proving their ability to *deliver more horsepower per dollar!*

Dyna-V utilizes the full performance possibilities of today's great synthetic fibers for belts—and modern metals for sheaves. Narrow belt top widths team up with narrow sheave grooves to create Dyna-V compactness. Narrow grooves reduce face width—save weight. Costs are lowered. Smaller diameter sheaves and shorter center distances multiply savings. With Dyna-V you cut costs on most initial installations and economize on belt replacements as well. In medium and high hp ranges these savings can be as much as 30%.

Dyna-V Sheaves decrease shaft overhang—increase bearing life. And Dyna-V Belts possess all premium qualities. Conditions requiring oil, heat, moisture resistance or static conductivity are met by Dyna-V's one grade—the finest. Ask your local Dodge Distributor. Or write us for Dyna-V Bulletin.



**CALL THE TRANSMISSIONEER** — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery".

**DODGE**
of Mishawaka, Ind.

**DODGE MANUFACTURING CORPORATION, 3300 UNION STREET, MISHAWAKA, INDIANA**

## Wherever in the world your industrial machinery operates...




# Shell Alvania Grease is there

**Other outstanding Shell Industrial Lubricants available world-wide**

**Shell Tellus Oils**—for hydraulic systems

**Shell Talona R Oil 40**—anti-wear crankcase oil for diesel locomotives

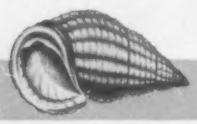
**Shell Rimula Oils**—for heavy-duty diesel engines

**Shell Turbo Oils**—for utility, industrial and marine turbines

**Shell Dromus Oils**—soluble cutting oils for high-production metalworking

**Shell Macoma Oils**—for extreme pressure industrial gear lubrication

**Shell Voluta Oils**—for high-speed quenching with maximum stability



**AN INTERESTING FACT!**
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the Alvania beauti.

Around the world, Shell Alvania Grease is available—under the same brand name and providing the same outstanding lubrication. This is assurance that your customers abroad will enjoy the same performance from your equipment that domestic customers rely upon.

Alvania® Grease offers these performance-proved advantages: (1) It provides safe lubrication at both high and low temperatures. (2) It won't wash out even in locations where water splashing can't be avoided. (3) It has built-in protection against rust and pitting of anti-friction bearings. And because this *one* multi-purpose grease is specially designed to satisfy as much as 90% of industrial grease needs, less servicing time is required; inventory costs are less; and there is less risk of misapplication.

No matter where your machinery is shipped, make Shell Alvania Grease your standard recommendation. Write for complete information.

## SHELL OIL COMPANY

50 WEST 50TH STREET.....NEW YORK 20, N. Y.
100 BUSH STREET.....SAN FRANCISCO 6, CALIFORNIA
IN CANADA: SHELL OIL COMPANY OF CANADA, LIMITED
505 UNIVERSITY AVENUE.....TORONTO 2, ONTARIO

SHELL

*"Jobs once considered impossible are now handled with ease . . . thanks to the photographic versatility of CRONAFLEX®"*

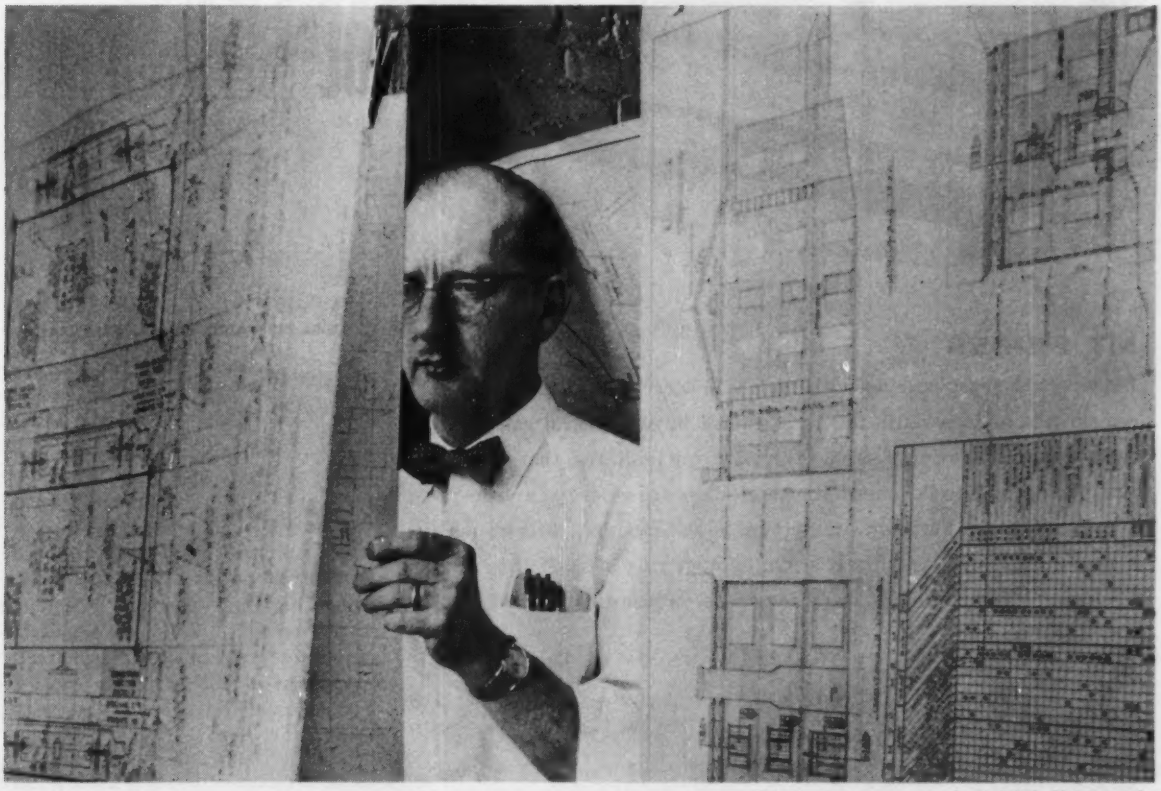
**—Mr. Harry Edelmann, President, En-Ser-Co, Inc., Cleveland, Ohio**

"Clients come to us with an enormous variety of needs," reports Mr. Edelmann, "and it's our responsibility to satisfy them all. That's why CRONAFLEX is the mainstay in our shop. The extreme versatility of these fine films helps us not only to improve the quality of existing work; but also enables us to devise new systems to meet the ever-changing requirements of our customers.

"For example," Mr. Edelmann continues, "we undertook the task of reproducing a set of 60-year-old production plates, containing handwritten copy, after every other method had failed. The plates were badly smudged and smeared. Using CRONAFLEX, we made crisp, sharply-etched reproductions, so legible they looked like ink copies. I'm convinced we couldn't have performed a job like that with any other material!"

Offering a complete range of engineering reproduction services, En-Ser-Co uses CRONAFLEX for the production of everything from plant layout charts and printed circuits to architectural renderings and map reproductions. Concludes Mr. Edelmann: "the consistent quality of CRONAFLEX, coupled with simplified processing and handling ease, permits far better work at savings of 20% or more to our customers."

If photographic versatility, consistent quality and greater end-cost savings are high on *your* list of requirements, there's a CRONAFLEX Engineering Reproduction Film to do the job. For details, just call your local Du Pont Photo Products sales office below.



*This advertisement was prepared exclusively by Phototypography.*

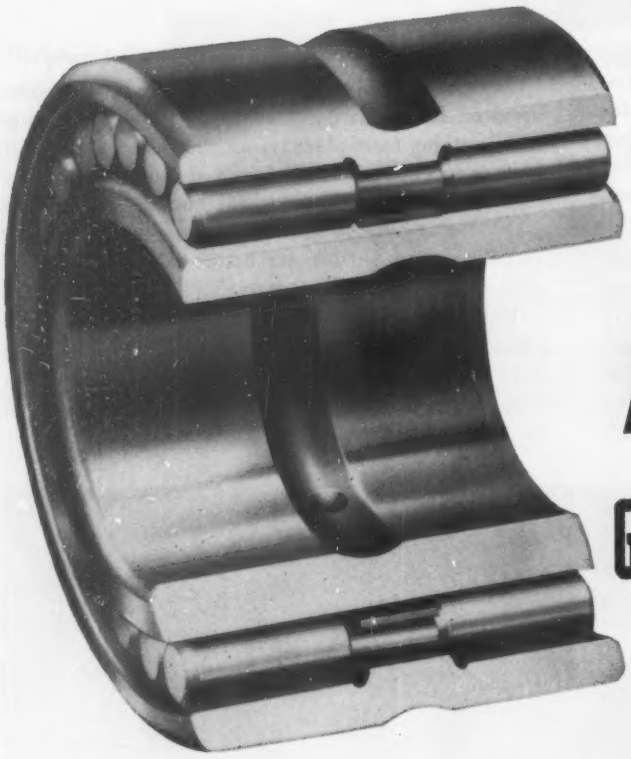
Mr. Edelmann inspects finished reproductions on CRONAFLEX as they hang on drying lines. "Fast drying time, because of its unique CRONAR® base, is another big advantage of CRONAFLEX," he states.

DU PONT
REG. U.S. PAT. OFF.

**BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY***

**Atlanta 18, Ga.**, 1737 Ellsworth Ind. Dr. N.W.; **Waltham 54, Mass.**, 45-4th Ave. (Boston); **Chicago 46, Ill.**, 4560 Touhy Ave., Edgebrook Sta.; **Cleveland 16, Ohio**, 20575 Center Ridge Road; **Dallas 7, Texas**, 1628 Oak Lawn Ave.; **Los Angeles 38, Calif.**, 7051 Santa Monica Blvd.; **New York 11, N.Y.**, 248 W. 18th St.; **Wynnewood, Pa.**, 308 E. Lancaster Ave. (Phila.); **Export**, Nemours Bldg., Wilmington 98, Del. **In Canada:** Du Pont of Canada Limited, Toronto.

# FOR EXTRA LOAD CAPACITY IN MINIMUM RADIAL SPACE use



# McGILL®

## GUIDEROL® BEARINGS

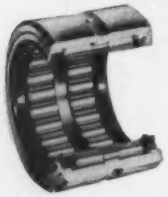
### MT SERIES

Here is a compact bearing with high load-carrying capacity. Its full complement of race-width rollers is guided by an integral rail in the outer race bore, providing strength and skewing limitation that prevents binding under controlled misalignment. Rollers are guided at any operational angle from horizontal to vertical — self-cleaning through open ends. Available with or without separate inner ring in shaft sizes from ½" to 9¼". Dimensionally interchangeable with ordinary heavy duty needle bearings.

### CT SERIES

Offer full type roller bearing capacity dimensionally interchangeable with ball and cylinder roller bearings of single and double row dimensions. The inner ring may be eliminated for further reduction of radial space.

**SEALED—AND STILL COMPACT**



No extra axial space needed for the sealed SG series GUIDEROL bearing. Seals are press-fitted securely in the outer race bore to provide the same width and performance advantages of standard GUIDEROL bearings. Contaminants are locked out, lubricants sealed in for those hard to re-lubricate applications. The SG series solves the problem of too-expensive auxiliary sealing assemblies.

Write for McGill's Bearing Catalog #52-A, for engineering data with dimensional and capacity information on McGill needle type roller bearings. Ask about special precision ball and roller bearings.



McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

*engineered electrical products*

McGILL®

*precision needle roller bearings*

## Blood Brothers Drive Assemblies help give power "pay-off" in

# TOUGH HOUGH PAYLOADER®

Many outstanding improvements have made this Hough Model H-90B Tractor Loader a proven leader in its field. Available with 1½, 3 and 5 cubic yard capacities, it offers a full 50° bucket-dumping angle, plus maximum lifting height and reach for loading large hauling units.

The lower-front drive shaft and lower-rear drive shaft used on this latest equipment were manufactured to exacting specifications by Blood Brothers. It is typical of the many quality drive assemblies Blood Brothers furnish for special equipment of all sizes.

Rockwell-Standard's Universal Joint Division offers a wide range of specialized engineering experience – involving everything from manual steering assemblies . . . to power take-off drives . . . to heavy-duty propeller shafts.

If you are planning or designing new equipment, consult our engineers for important savings in time and money. A letter or phone call will bring cooperative, friendly, experienced assistance.

***Write for complete information***

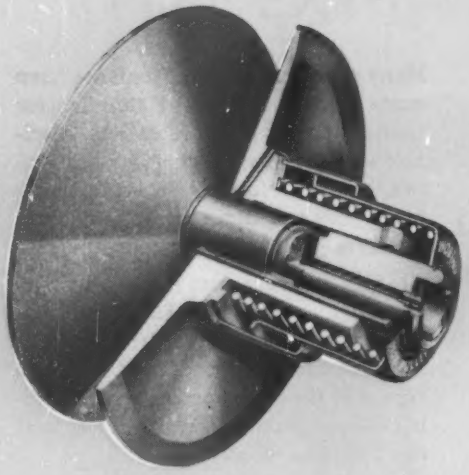


*Another Product of* **ROCKWELL-STANDARD CORPORATION**

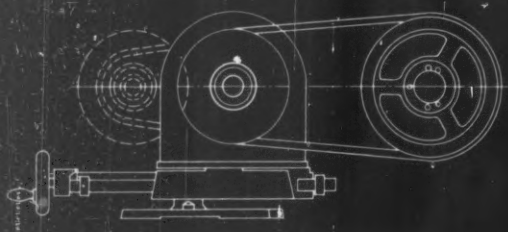
Universal Joint Division, Allegan, Michigan

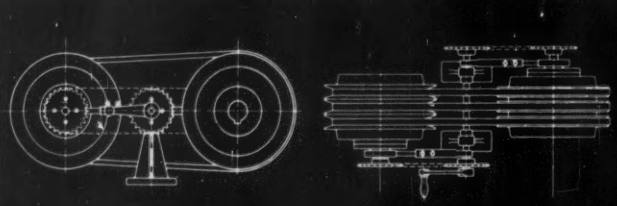



*Circle 454 on Page 19*









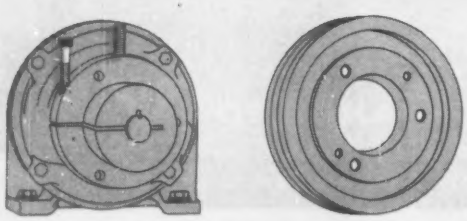
**PROBLEM:** Need 15 hp and up to 3:1 continuous speed variation with equipment running.

**SOLUTION:** For horsepowers from ⅛ to 15, use Worthington Motor Pulley drive with Anglematic motor base. The Anglematic motor base allows continuous speed control while maintaining belt alignment. It keeps the motor pulley design simple, trouble-free; two-piece companion sheaves have separate hubs and the 2 "Golden Screws" for easier, more dependable installation.

**PROBLEM:** Need less than 2:1 speed variation on 500 hp installation, with equipment running.

**SOLUTION:** Use the motion control Multi-Pitch sheaves. For fixed center drives and maximum variation, use a double motion control drive arrangement. For applications not requiring speed changes with equipment running, choose the less expensive stationary control Multi-Pitch sheave.

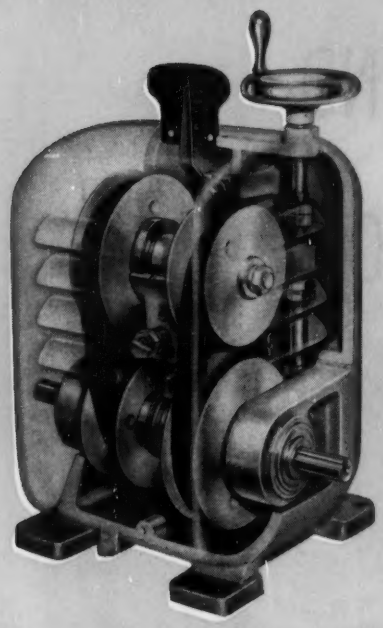
# VARIABLE SPEED PROBLEMS

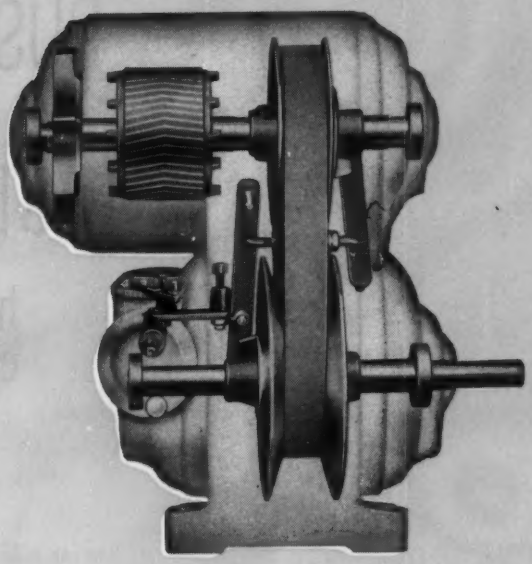


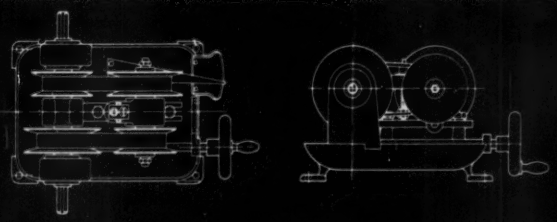
You need, of course, just one right answer to any variable speed problem. But if your answer is based on a choice from four stock Worthington variable-speed drive types and their hundreds of standard variations, chances are your final solution will be the best one. Certainly, you'll get compact design, accurate speed control and long

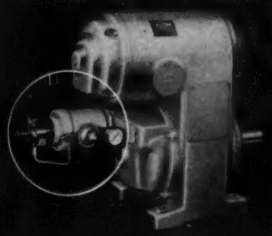
Motor Pulley and Multi-Pitch Sheave drives require companion sheaves. Both types of Worthington companion sheaves are equipped with the famous QD hub with the "Golden Screws" for permanent alignment and prevention of key drift. For longest belt life, select Worthington-Goodyear belts.

←









**PROBLEM:** Need 150 to 3000 rpm stepless speed variation while equipment is running.

**SOLUTION:** Use Worthington Allspeed Drive that can give up to 20:1 speed variation without stopping equipment. Compact design has straight through shaft for very simple installations with direct or other couplings. A skeleton frame or enclosed frame, in horizontal or upright types make installation even more easy and compact and any frame can be at any angle.

**PROBLEM:** Need automatically controlled speed variation as high as 10:1 in continuous process.

**SOLUTION:** Use sensing or monitoring device that converts production variations such as pressure, temperature, time, speed or liquid levels—to pneumatic pressures. Connect it to Worthington Variable Speed Motor drive equipped with pneumatic cylinder that actuates speed variation in direct proportion to any change in input signal. Electric, lever and remote hand controls also available. Horsepowers from ½ to 25.

# . . . FOUR STOCK ANSWERS

*Circle 455 on Page 19*

equipment life—all at a very competitive cost for the job you want done.

To help you, Worthington variable speed drive catalogs contain complete "how-to-figure-it" engineering information, as well as product information. You can get them from your nearest Worthington representative or distributor listed in the Yellow Pages. Or use the coupon at the right.

WORTHINGTON

**WORTHINGTON CORPORATION**
Section 79-31, Oil City, Pa.

Please send me your new catalogs on the following variable speed drive components:

- ☐ Multi-pitch Sheaves
- ☐ Motor Pulley Drives (1 to 15 hp)
- ☐ Motor Pulley Drives (Fractional hp)
- ☐ Motor Drives
- ☐ Allspeed Drives
- ☐ Variable Speed V-Belts

NAME_____

COMPANY_____

ADDRESS_____

CITY AND STATE_____

# BUSTLE-BOUND or FAST 'N' SMOOTH

## how does your chrome plating stack up?





You can keep your chrome-plating process in step with today — with Diamond CPA 1800®.

For example: Viking Copper Tube Co., of Cleveland, Ohio — with mandrels plated by the CPA 1800 process — draws 1500 feet of copper tubing per minute to extremely close tolerances with almost unbelievably reduced deterioration in machine tools!

This same job-proven additive is available to you. To increase plating speed and covering power. To allow a broader operating range. To simplify anoding and produce a brighter, harder coating. To improve the metallurgical characteristics of chromium plate.

In short: Diamond CPA 1800 can cut your unit costs and save you money. Diamond developed it. Your Diamond CPA 1800 Distributor can supply it where and when you need it.

For further information write or call Diamond Alkali Company, 300 Union Commerce Building, Cleveland 14, Ohio.

**Diamond Chemicals**



Circle 456 on Page 19

Circle 457 on Page 19→



# Coupling a billion horsepower

Fast's Couplings are the choice of more industrial equipment manufacturers than any other gear-type coupling. Added fact: The Fast's line is more complete, with more applications. So it takes no more than a conservative estimate of total horsepower ratings to pass the billion mark.

Reasons for this popularity? Every Fast's Coupling brings you superb engineering only the original gear-type coupling can deliver. Smooth-running units that are designed to outlast the machines they connect. Rapid service from experienced field engineers backed by outstanding stock facilities.

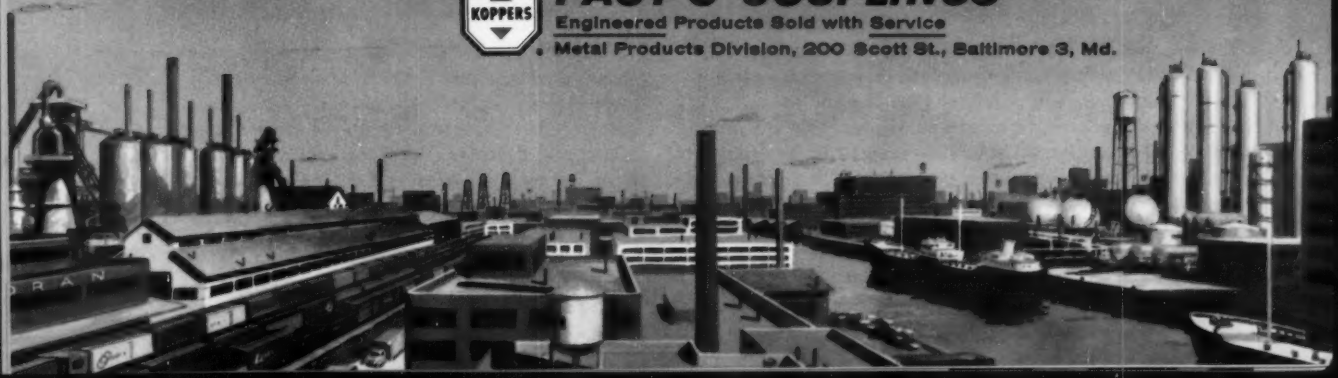
Second billion, here we come...

KOPPERS

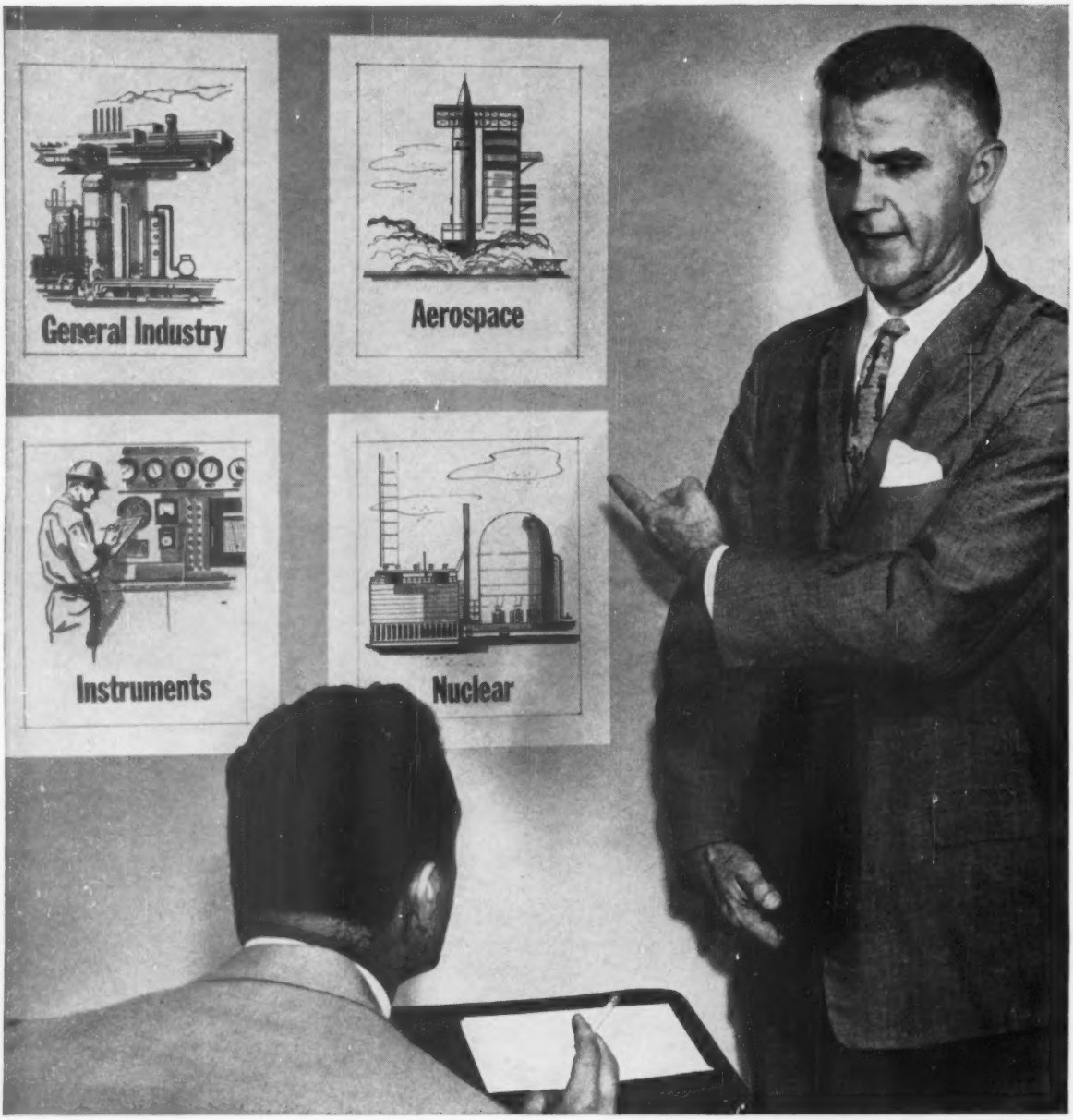
**FAST'S COUPLINGS**

Engineered Products Sold with Service

Metal Products Division, 200 Scott St., Baltimore 3, Md.



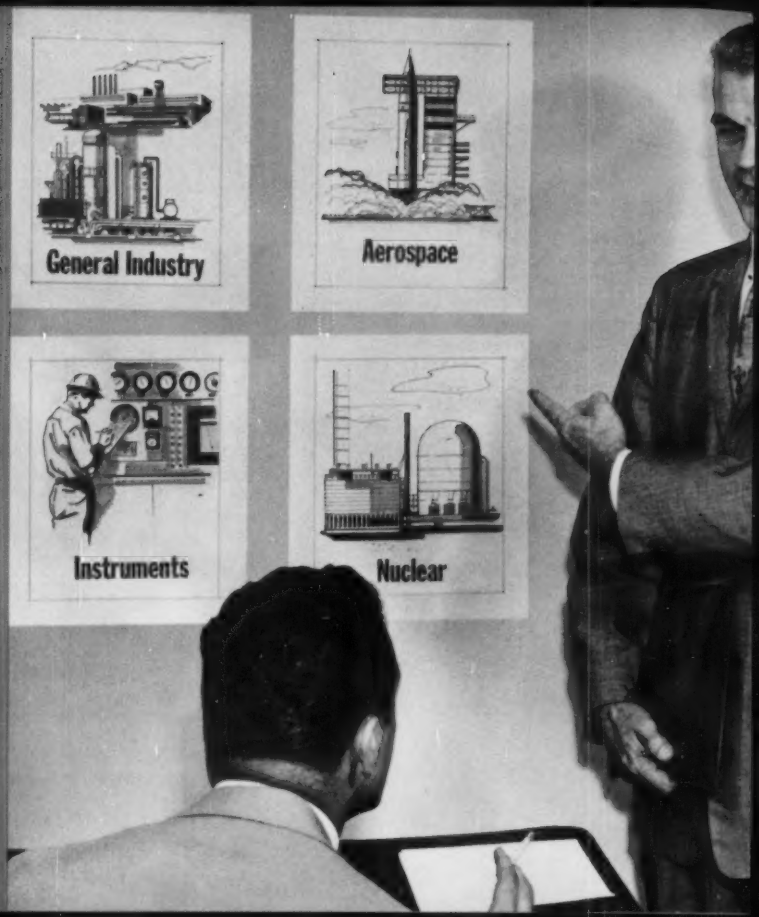
# *Things to know about Superior tubing in creating new designs*




Superior small-diameter tubing is a versatile product, almost unlimited in its adaptation to design requirements. Ours is a specialty mill equipped to produce tubing in any shape, to any practical mechanical property range, and to the most exacting specifications. We offer more than 120 analyses in a wide range of sizes to serve practically all industries—aerospace, instrument, nuclear, electrical, chemical, electronic, to name a few. Some classifications of Superior tubing are illustrated on the facing page. Characteristics, materials usually specified, and range of sizes for a number of the more widely used types are given in "Facts about Superior Tubing." Tear it out and use it as a handy reference. And if you have a problem requiring special information, write us giving complete details. It will receive our most careful attention. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

LIFT OUT AND FILE
FOR FUTURE REFERENCE

# FACTS ABOUT SUPERIOR TUBING




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## SUPERIOR TUBING FOR GENERAL INDUSTRY

### SUPERIOR (SAE) HYDRAULIC TUBING

**Characteristics** • Easy to bend and flare with no loss of ductility in storage or service • Consistent uniformity through careful inspection of raw material and tubing in process • Bright scalefree OD and ID through controlled atmosphere annealing • Smooth ID by mandrel drawing close to finish size • Assured cleanliness by hot solvent degreasing before shipment • 100% hydrostatic testing to recommended working pressures • Flare-inspected quality based on 35% increase of OD • Rust-preventive treatment before wrapping and boxing

**Materials usually specified**—Nonaging carbon steel with 0.12% max. carbon content.

**Range of sizes**—⅛ to 1⅛ in. OD (above ⅝ in. OD max. wall is .035 in.) available in cut, multiple or random lengths up to 28 ft. Longer lengths can be supplied on special order.

### DIESEL FUEL INJECTION TUBING

(for pressures from 3000 to 9000 psi)

**Characteristics** • Resistant to stresses of pressure and vibration • Ductile enough to be cold swaged and upset and to be cold formed into bends and loops without excessive springback • High burst strength and fatigue resistance • Clean ID, conditioned for removal of fissures and other defects • ID free from radial cracks deeper than .005 in. or 5% of wall thickness, whichever is less • Hydrostatically tested to various pressures according to specifications • Annealed at finish in controlled atmosphere furnaces to produce a soft, ductile and scalefree product • Fracture tests performed when requested

**Materials usually specified**—Types C-1008 and 4615 are most commonly specified for this application. Alloy and stainless steel tubing for pressures above 9000 psi and greater corrosion resistance is available.

**Range of sizes**—ODs to ⅝ in. max. IDs to 3/16 in. max.

### SUPER PRESSURE TUBING

(15,000 to 100,000 psi)

**Characteristics** • Produced from specially selected raw materials • Inside surfaces are conditioned to remove fissures and other defects and insure clear, smooth surface • 100% hydrostatically tested to recommended working pressures • Two types: single wall mechanical and double wall (or composite), made from two tubes • Produced in annealed condition and in ⅛ hard temper and to mechanical properties specified by customer • Laboratory inspected for defects before shipment

**Materials usually specified**—Normally produced from Types 304, 316, 321, 347 stainless steel, and 4130 alloy steel.

**Range of sizes**—⅛ through ¾ in. OD in lengths up to 30 ft.

### NEEDLE TUBING

**Characteristics** • Excellent mechanical properties up to 650°F • Good corrosion resistance • Strict dimensional tolerances • Exceptional cleanliness

**Materials usually specified**—Usually Type 304 stainless is specified, but tubing from other materials can be supplied.

**Range of sizes**—28 standard sizes and gages from 6 to 33 in random straight lengths from 2 to 12 ft. and also in precision cut lengths.

**Tempers**—Needle temper, special hard drawn. Can be produced, however, in other tempers, such as full hard, half hard, ¼ hard and fully annealed.

## CARBON AND ALLOY STEEL MECHANICAL TUBING

**Characteristics** • Seamless • Uniformly high quality with close tolerances • Consistent mechanical properties • Supplied in many different shapes • Offered in a number of different tempers and finishes

**Materials usually specified**—C-1008, MT-1010, MT-1015, Leaded C-1020, MT-1020, C-1025, C-1035, C-1045, E-1095 and ingot iron. Also 4130, 4132, 4140, 4150, 8630 and 52100.

**Range of sizes**—Normal size range is .010 through ⅝ in. OD. Above ⅝ in. OD, max. wall is .035 in.

## STAINLESS MECHANICAL TUBING

**Characteristics** • Seamless and WELDRAWN* • Uniform mechanical properties • Consistently high quality • Close tolerances • Corrosion resistant

*Superior Tube trademark, reg. U.S. and Canada

**Materials usually specified**—Among the materials usually specified are Types 303, 304, 305, 309, 310, 316, 321, 347, 348, 403, 410, 430, 430Ti, 446 and 502.

**Range of sizes**—Normally .012 through ⅝ in. OD. Above ⅝—to 1⅛ in. OD—max. wall is .035 in. In certain analyses, ODs to 2½ in., max. wall .025 in.

# SUPERIOR TUBING FOR INSTRUMENTS

## CAPILLARY TUBING

**Characteristics** • Extremely clean and smooth ID surface • Good fabricability for joining by soldering, brazing or welding • Ductility for ease in bending or forming • Close tolerances for ID uniformity • Uniform flow characteristics • Long lengths—up to 3000 ft. to simplify joining, assure greater ID uniformity, reduce scrap, lessen number of setups required

**Materials usually specified**—Types 347, 321, 316 stainless, which generally offer the best combination of corrosion resistance and fabrication characteristics. Other materials offered are Types 304 and 446 stainless, nickel, Monel,* Inconel* and C-1008 carbon steel.

*Reg. TM International Nickel Co.

**Range of sizes**—ODs from .030 to .187 in., ID minimum .004 in. The wall thickness is generally greater than the inside diameter.

## BOURDON TUBING

**Characteristics** • Good resistance to drift • Low hysteresis • Ease of joining by welding or soldering • Corrosion resistance from organic and inorganic media on both inner and outer surfaces • Highest possible uniformity in size and close tolerance control • Good ductility for severe fabrication

**Materials usually specified**—Beryllium copper; Ni-Span C;* K Monel;* and 4130 alloy steel. Other materials sometimes specified: Types 304, 316, 403 stainless, and Inconel X.*

*Reg. TM International Nickel Co.

### Range of Sizes

**Round tubing.** Many instrument concerns buy round tubing and form it into Bourdon shapes. Superior supplies this made in accordance with its special Bourdon-quality procedures. Such tubing is of higher quality than standard mechanical because of the selected raw material used, careful in-process conditioning, and microscopic inspection at finish. ODs from ⅛ through 1⅛ in.—above ⅝ in., maximum wall limit is .035 in.

**Shaped tubing.** All shaped Bourdon tubing is manufactured to customers' specifications. The size restrictions are limited to those which can be formed from the maximum round sizes given above. Most needs of the industry are supplied by flat oval and elliptical shapes, but the "D" shape is also produced.

## BELLOWS TUBING

**Characteristics** • Excellent ductility to withstand severe fabrication and repeated flexing • Resistance to corrosion and high temperatures • Freedom from carburization • Uniform wall thickness and temper • Smooth surfaces to enhance fatigue life

**Materials usually specified**—Stainless Types 316, 321 and 347 are the analyses most commonly selected. Others are Monel, Inconel, Grade A Nickel,* and Inconel X. WELDRAWN can be supplied where close concentricity and wall uniformity are paramount.

*Reg. TM International Nickel Co.

**Range of sizes**—ODs from ⅜ to 1⅛ in., wall thickness from .005 to .025 in. Thin walls, often under .010 in., are specified to permit satisfactory convoluting.

## TUBING FOR THERMOCOUPLES

**Characteristics** • Good scaling resistance at high temperatures • Good corrosion resistance • Good fabricability

**Materials usually specified**—Constantan and ingot iron are the two materials most often required for thermocouple applications. Used together, these form the well-known iron-constantan thermocouples, useful for temperatures up to 1000°F.

**Range of sizes**—The most commonly used sizes of tubing for tubular-type thermocouples are .5625, .4062, .250, .125 and .062 in. OD, with walls ranging from .010 to .035 in., depending on the final application of the thermocouple.

## THERMOCOUPLE PROTECTION TUBING

**Characteristics** • Adaptability to temperature extremes (−300 to +2100°F) • High scaling resistance • High shock, fatigue and corrosion resistance • Close tolerances • Spotlessly clean, smooth inner surface

**Materials usually specified**—Thermocouple protection tubing is generally specified in some type of stainless steel or nickel base alloy, 300 to 400 Series, Hastelloy C,* Grade A Nickel, Inconel, Monel, 30% cupronickel, and titanium. The analysis is dependent on the temperature and corrosive effects that will be encountered.

*Reg. TM Haynes Stellite Co.

**Range of sizes**—Sizes most commonly used are ⅛ to ½ in. OD, walls .007 to .035 in., but larger or smaller ODs and walls can be supplied. In fact this tubing is available in Superior's complete size range—from .010 to ⅛ in. OD. Long lengths in coil form, up to 500 ft., depending on size, are available.

## LINKAGE TUBING

**Characteristics** • Light weight to enhance responsiveness of the instrument • Rigidity to promote accuracy of transmission • Ease of fabrication • Good corrosion resistance

**Materials usually specified**—Hypoflex,® Superior's stainless steel 304 hypodermic needle tubing, is widely preferred due to high strength and corrosion resistance. Materials frequently specified to meet particular corrosion requirements are Monel, Grade A Nickel, Inconel and titanium. Titanium also has the merit of light weight and unusually good corrosion resistance.

**Range of sizes**—Because of the need for light weight and rigidity, ODs under .250 in., and walls thin as practicable, i.e., from .015 to .035 in., are specified. But any OD, ID or wall thickness within the Superior range can be supplied. (Send for Data Memorandum #9 giving a full listing of standard gages for hypodermic needle tubing.)

## RECORDING PEN TUBING

**Characteristics** • Good corrosion resistance against fast-drying inks of any type • Stiffness • Resistance to wear • Close tolerances to meet weight limitations • Close control of ID to enhance good ink flow

**Materials usually specified**—Because of the corrosion resistance required, stainless steel 300 Series is most often specified. Hypoflex, Superior's standard hypodermic needle tubing, of stainless Type 304, is also frequently chosen. Other desirable materials are nickel, Monel, Haynes 25* and Inconel.

*Reg. TM Haynes Stellite Co.

**Range of sizes**—Generally ODs from .028 to .050 in., walls from .00625 to .0085 in., are found to promote the best flow rate for ink-carrying systems. In some cases a smaller size tube is required for the pen point to make possible tracing a fine line on the chart. The pen nib ID runs between .007 and .009 in.

## WAVEGUIDE TUBING

**Characteristics** • Extremely close tolerances • Excellent corrosion resistance • Sharp corners • Low thermal conductivity

**Materials usually specified**—Type 304 stainless steel. Also carbon, alloy and other stainless steels, nickel and nickel alloys, cupronickel, and beryllium copper.

**Range of sizes**—Inside dimensions from .122 x .061 in. to 1.872 x .872 in. Wall thicknesses from .010 to .025 in.

## GAS CHROMATOGRAPHY TUBING

**Characteristics** • Uniformity of inside surface for even deposit of chemical coating • Smoothness of this surface —for accuracy of evaluation—must be maintained over relatively long lengths, as in the case of capillary tubing.

**Materials usually specified**- Stainless steel Types 304, 316, 321 and 347—Type 304 is the most economical and the one most often specified. 30% cupronickel has also been ordered for this application.

**Range of sizes**—The standard sizes most frequently used are .062 in. OD by .010 or .020 in. wall; ¼ in. OD by 3/16 in. ID; standard needle tubing sizes below .042 in. OD. Long length coils—100, 200, 300, 500 and 1000 ft.—are specified in coil diameters of 18, 24 and 36 in.

# SUPERIOR TUBING FOR AIRCRAFT, MISSILES AND ROCKETS

## SUPER ALLOY TUBING

**Characteristics** • Minimum of 1000-hr. stress rupture strength of 25,000 psi at 1200°F • Resist progressive scaling and other types of corrosion • Will not fail through brittle fracture or show excessive grain growth at operating temperature

**Materials usually specified**—Type 316 stainless; A-286;[1] Inconel X; Inconel 702;[2] Hastelloy X;[3] Hastelloy C;[3] Haynes 25;[3] Waspalloy.

[1]Registered TM Allegheny Ludlum Steel Corp.
[2]Registered TM International Nickel Co.
[3]Registered TM Haynes Stellite Co.

**Range of sizes**—.012 through 5/8 in. OD; above 5/8 to 1 1/8 in. OD, max. wall is .035 in.

## TUBING FOR FLUID-HANDLING LINES—HYDRAULIC, FUEL, OIL

**Characteristics** • Ductility for ease in bending and forming • Flarability for ease in making installations and connections • Clean and smooth surface finishes • High strength and fatigue resistance • Good corrosion resistance

**Materials Usually Specified**

**For hydraulic lines**—Stainless steel grades 304, 321 and 347 in both seamless and WELDRAWN forms. Sizes .012 to 1.125 in. OD. Supplied in either annealed or ⅛ hard temper.

**For fuel lines**—Stainless steel grades 304, 321 and 347 in both seamless and WELDRAWN forms. Sizes .012 to 1.125 in. OD.

**For oil lines**—C-1008 low carbon steel and Type 410 stainless steel. Seamless only. Sizes .012 to 1.125 in. OD.

## AIRCRAFT HEAT EXCHANGER TUBING

**Characteristics** • Strict adherence to highest commercial and military combined specifications • Completely controlled quality—wall uniformity paramount—extra close tolerances • Precise surface inspection—100% flare and pressure tested • Desirable brazing and welding qualities

**Materials usually specified**—Stainless steel Types 304, 304L, 310, 316, 316L, 321 and 347. Both Seamless and WELDRAWN are available, but usually WELDRAWN is chosen.

**Range of sizes**—The wall thickness most commonly specified ranges from .004 to .016 in.

## THRUST CHAMBER TUBING

**Characteristics** • High corrosion resistance • Ability to withstand severe fabrication • Excellent heat conductivity • Retention of properties during storage • Closely controlled mechanical properties

**Materials usually specified**—Grade A Nickel and Types 304 and 347 stainless steel. Also suitability of columbium is indicated. Inconel X and Nionel* are also being considered. Grade A Nickel, however, is the most commonly used tubing material.

*Reg. TM International Nickel Co.

**Range of sizes**—½ to 1⅛ in. OD with wall thicknesses from .012 to .035 in.

## SUPERIOR TUBING FOR NUCLEAR APPLICATIONS

## TUBING FOR FUEL ELEMENT CLADDING

**Characteristics** • Chlorine residuals kept to minimum • Closely controlled chemical composition to meet strict nuclear requirements • Selected high-quality raw materials • ID and OD bright and free from discoloration, carburization, grease, dirt, metal particles, and other foreign matter • Held to close dimensional tolerances • Excellent ductility and fabricability • Good strength at elevated temperatures

**Materials usually specified**—Types 348, 304, 304L, 316 and 347 stainless. Also zirconium, Zircalloy 2 and 4, columbium and vanadium.

**Range of sizes**—.080 to 1⅛ in. OD, walls from .007 to .040 in.

## HEAT EXCHANGER TUBING

**Characteristics** • Selected high-quality raw materials • ID and OD bright and free from discoloration, grease, dirt, metal shavings, metal particles, and other foreign matter • 100% visual, dimensional and hydrostatic testing • Mechanical properties established by our Metallurgical Department

**Materials usually specified**—Types 304, 304L, 316, 347 and 348. Also Inconel.

**Range of sizes**—5/16 to ⅝ in. OD, with walls from .035 to .065 in.

**SUPERIOR TUBE COMPANY**

**NORRISTOWN, PA.**



Form 860-5M-DS Printed in U.S.A.

**Superior Tube Company**
**Norristown, Pa.**

Send me complete information on the following types of tubing:

- ☐ SAE Hydraulic Tubing
- ☐ Needle Tubing
- ☐ Super Pressure Tubing
- ☐ Diesel Fuel Injection Tubing
- ☐ Mechanical Tubing
- ☐ Capillary Tubing
- ☐ Bourdon Tubing
- ☐ Bellows Tubing
- ☐ Tubing for Thermocouples
- ☐ Thermocouple Protection Tubing
- ☐ Waveguide Tubing
- ☐ Gas Chromatography Tubing
- ☐ Super Alloy Tubing
- ☐ Tubing for Aircraft Fluid-Handling Lines
- ☐ Heat Exchanger Tubing for Aircraft Applications
- ☐ Thrust Chamber Tubing
- ☐ Heat Exchanger Tubing for Nuclear Applications
- ☐ Tubing for Fuel Element Cladding

I am considering small-diameter tubing for the following end use:

.....

.....

.....

OD .... ID .... Wall Thickness .... Temper ..... Lengths .....

Service conditions (temperature range, corrosion if any, expected length of service, vibration, and any other pertinent facts).....

.....

.....

Name.....Title.....

Company.....

Street.....

City.....Zone.....State.....

First Class
Permit No. 9,
Collegeville,
Pa.

**BUSINESS REPLY MAIL**

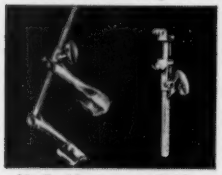
No Postage Stamp Necessary If Mailed in the United States

**SUPERIOR TUBE COMPANY**

**COLLEGEVILLE**

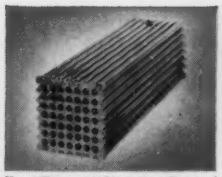
**PENNSYLVANIA**

***Check this variety of tubing products for your design applications***


Medical Instrument Tubing

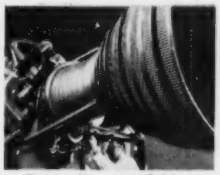

Super Pressure Tubing

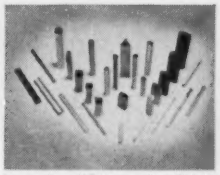

Tubing for Cable Connectors

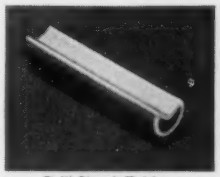

Fuel Element Cladding Tubing

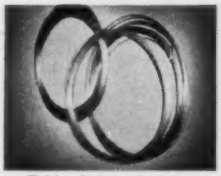

Glass Sealing Tubing

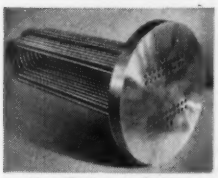

Tapered Tubing

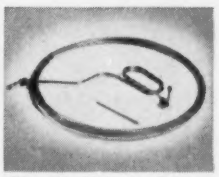

Thrust Chamber Tubing

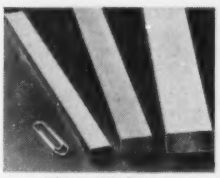

Shaped and Telescoping Tubing


Drill Shank Tubing


Tubing in Long Lengths

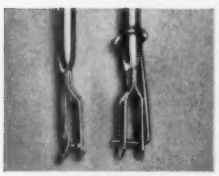

Heat Exchanger Tubing

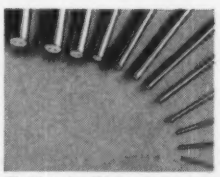

Diesel Fuel Injection Tubing

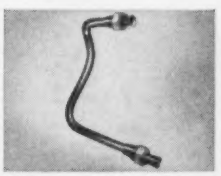

Waveguide Tubing

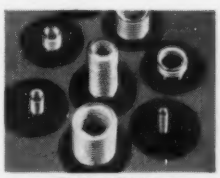

Firearms Tubing

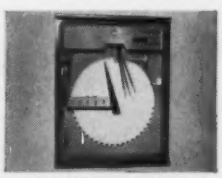

Aircraft Structural Tubing


Linkage Tubing

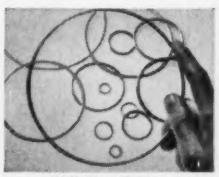

Tubing for Thermocouples

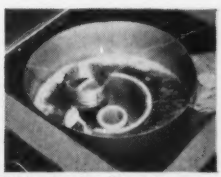

SAE Carbon Hydraulic Tubing


Bellows Tubing

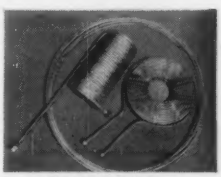

Recording Pen Tubing


Reactive Metals Tubing

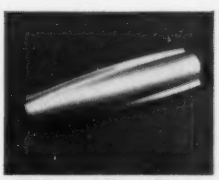

"O" Ring Tubing

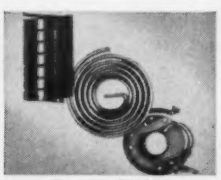

Tubing for Gas Chromatography

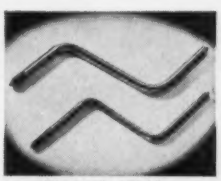

Capillary Tubing

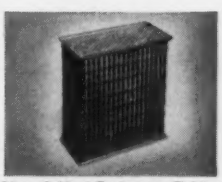

Beverage Tubing

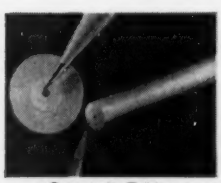

Needle Tubing

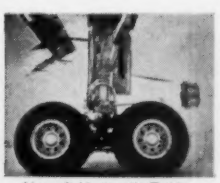

Ribbed and Finned Tubing

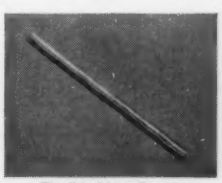

Bourdon Tubing

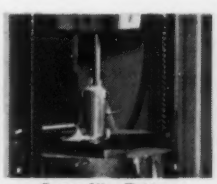

Mechanical Tubing

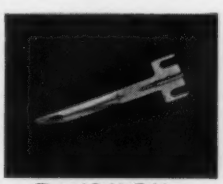

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Liquid flow through a cross section of a Malleable differential carrier.

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Molten metal flows evenly into all parts of the mold, then solidifies into pre-shaped parts with uniformly dependable properties throughout. Malleable iron castings will stand up under extremes of tension, impact, torsion, shear, fatigue, wear, heat, cold, and corrosion. They also offer maximum economy, are easy to work, and are versatile enough for parts ranging from a few ounces to hundreds of pounds.

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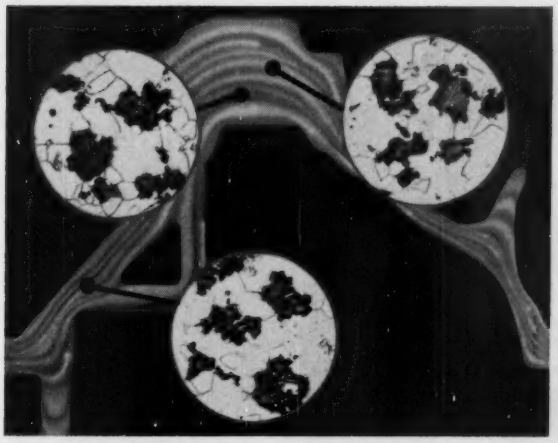
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CASTINGS COUNCIL

For details on Malleable's uniformity and reliability contact any company listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

# Malleable Castings...
# Uniformly Dependable All The Way Through!

Section a Malleable iron casting . . . check it under the microscope. You will find it shows a similar microstructure all the way through . . . and, therefore, gives you unvarying strength, toughness, and easy machinability.



Structural uniformity in a typical Malleable casting is seen in these micrographs from thick and thin, center and near-surface areas of the automotive differential carrier shown in the color illustration. Samples are magnified 100 times after 3% nital etch.

## Uniformity Assures Design Versatility and Easy Machinability

Malleable's structural uniformity and unvarying strength permit designs of any practical configuration based on the functional requirements of the part. The malleablizing process relieves internal stresses, and assures fast, problem-free machining.



## The Proof Is In The Using

The ultimate proof of a material's quality comes from actual use by customers. Truck and car torsion arms absorbing millions of road shocks, vital tractor parts performing equally well in the Sahara and the Antarctic, and thousands of other applications provide continuous proof of Malleable's unexcelled uniformity and reliability.

## Free Assistance and Information

Any member of the Malleable Castings Council will be pleased to assist you in making engineering decisions for effective use of Malleable castings. For further information, call or write today to any of the companies listed below for *Data Unit No. 103 "Uniformity"*, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.



## For Quality and Economy... Use MALLEABLE

**For Service In Your Area Contact...**

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Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

**DELAWARE**
Eastern Malleable Iron Co., Wilmington 99

**ILLINOIS**
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

**INDIANA**
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

**IOWA**
Iowa Malleable Iron Co., Fairfield

**MASSACHUSETTS**
Belcher Malleable Iron Co., Easton

**MICHIGAN**
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

**MINNESOTA**
Northern Malleable Iron Co., St. Paul 6

**MISSISSIPPI**
Mississippi Malleable Iron Co., Meridian

**NEW HAMPSHIRE**
Laconia Malleable Iron Co., Laconia

**NEW YORK**
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division, Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

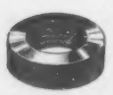
**OHIO**
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

**PENNSYLVANIA**
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

**TEXAS**
Texas Foundries, Inc., Lufkin

**WEST VIRGINIA**
West Virginia Mall. Iron Co., Point Pleasant

**WISCONSIN**
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46



Belleville



Compression



Conical



Die



Discs



Drawbar



Energy Cartridge



Extension



Flat



Garter



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Hourglass



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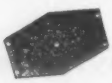
Clips



Electronic Coils



Fasteners



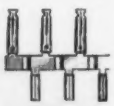
Plates



Retainers



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## Associated Spring Corporation

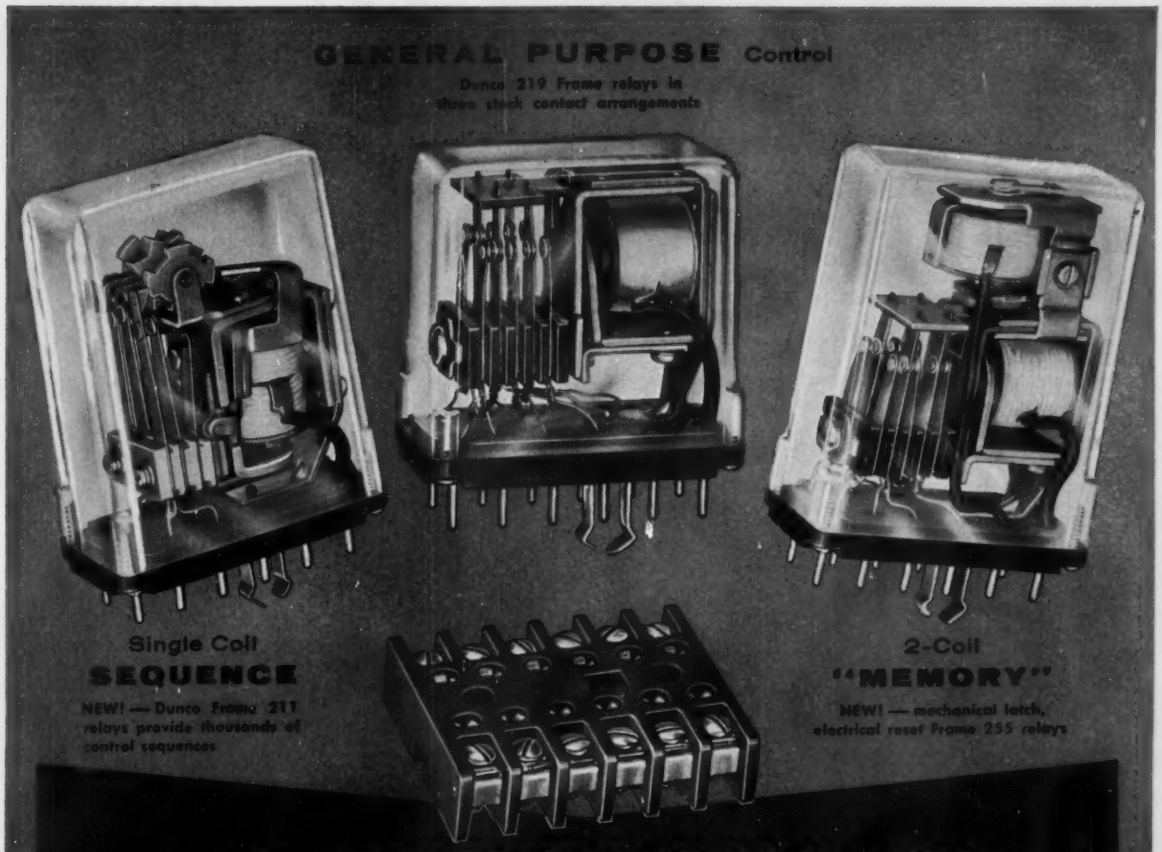
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Circle 460 on Page 19




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# Simplified, Economical Industrial Control

This dependable Dunco relay "family" paves the way to practically any needed industrial control sequence, "memory" or operational circuitry feature.

Smaller, moderately priced and requiring less operating power, Dunco 219 Frame relays have revolutionized many control panels previously "over relayed" with larger, more costly contactor type units than needed.

Now, in matching types, Dunco offers 255 mechanical latch, electrical reset and Frame 211 sequence relays.

All feature 12-pin plugs with heavy-duty industrial sockets. Contacts are conservatively rated at 10 amperes. Standard 150 volt electrical spacings are used throughout. All three types are designed for maximum control panel simplification and in minimum size for dependable service over millions of operations.

Write for Data Bulletins on any type to Struthers-Dunn, Inc., Pitman, N. J.

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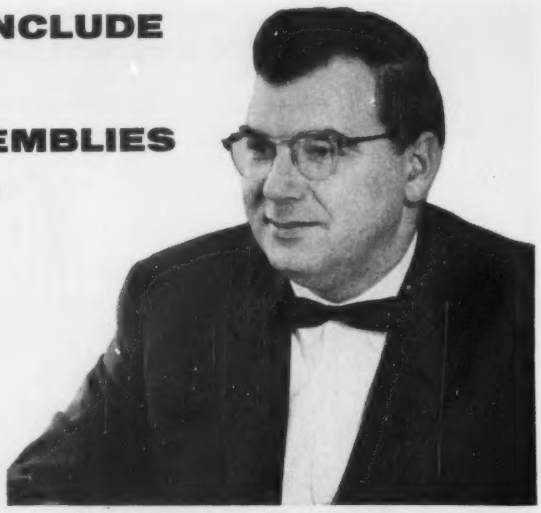
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# SERVICES EXPANDED TO INCLUDE PRODUCTION OF INSTRUMENT BEARING ASSEMBLIES

*By* **RICHARD H. CHERWIN,** *Executive Vice President*
*New Hampshire Ball Bearings, Inc.*



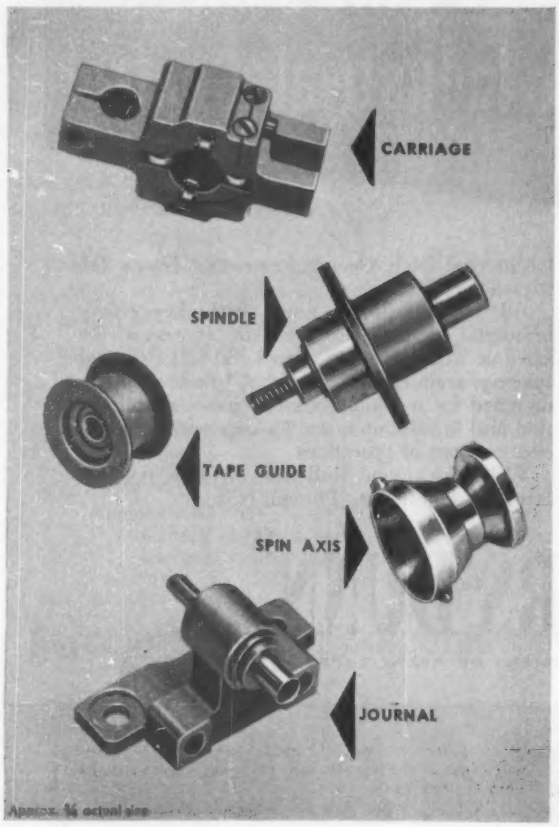
New Hampshire Ball Bearings, Inc., has established a separate facility—the Rotassembly Division—for the manufacture of instrument bearing assemblies to customer specifications. Production of shafts, housings, and pulleys of various configurations your designs may require is also included in this newest of services to instrument makers. We believe our experience in the manufacture of miniature and instrument ball bearings makes this a logical expansion of our activities.

This new service can help you if you are having problems in any of these areas:

Purchasing and handling instrument ball bearings;
Cost of assembling such bearings into units with proper fits;
Cost of purchasing various components from separate sources with delays caused by un-co-ordinate deliveries;
Cost and difficulty of manufacturing components;
High rate of rejects and costly tear-down of assembled end-products to correct failures.

## FREE DESIGN STUDY AND COSTING

Activity here starts from designs submitted by you. Without obligation, experienced application and production engineers, also Division technicians, study your drawings with regard to these factors: Will the bearings function as required by the application? Can selection and mounting of the bearings be modified for better performance? Is the assembly a type and size compatible with NEW HAMPSHIRE's experience and equipment?




## PRECISION MANUFACTURE

Instrument bearing assemblies accepted for manufacture are produced on the same types of precision machines that equip our Bearing Facility. Employing techniques developed to manufacture NEW HAMPSHIRE Bearings to ABEC Class 7 and better tolerances, components of your unit are ground to tolerances required for proper, easy assembly. Costly rework and refitting are eliminated. Competent technicians staffing the Rotassembly Division are thoroughly experienced in custom work in cost-lowering production quantities.

## ASSEMBLY AND INSPECTION FOR TROUBLE-FREE PERFORMANCE

Assembly and inspection of instrument bearing assemblies are done on the same equipment used to process NEW HAMPSHIRE miniature and instrument ball bearings. In dust-free, temperature-controlled facilities, each component of your mechanical unit is critically inspected and tested before assembly, then the unit is functionally tested after assembly. Performance levels required of them are the same as for NEW HAMPSHIRE Bearings and fitting practices followed during assembly as outlined in the "Design & Purchasing Manual." Instrument bearing assemblies shipped to you are ready for installation into your products.

## MANUFACTURE IS RESTRICTED

Manufacture is restricted to mechanical units in which correct installation and function of bearings are major critical elements in the performance of the assembled unit. We are not manufacturers of gears, gear trains, gear boxes, motors or electrical components and we are not qualified to produce these items. Relationship to instrument bearings is a primary qualification for all assemblies we elect to manufacture; it is in such types that our experience can best help you.

## INQUIRIES INVITED

If you wish more information about the Rotassembly Division — and our newest service to instrument makers — write or phone collect to the Regional Office in your area or the Main Plant in Peterborough.

**WESTERN REGION**
1540 North Highland Avenue
Hollywood 28, California
HOllywood 4-0208

**EASTERN REGION**
61 Cutter Mill Road
Great Neck, New York
HUnter 2-8633

**CENTRAL REGION**
566 Northwest Highway
Des Plaines, Illinois
VAnderbilt 7-6646

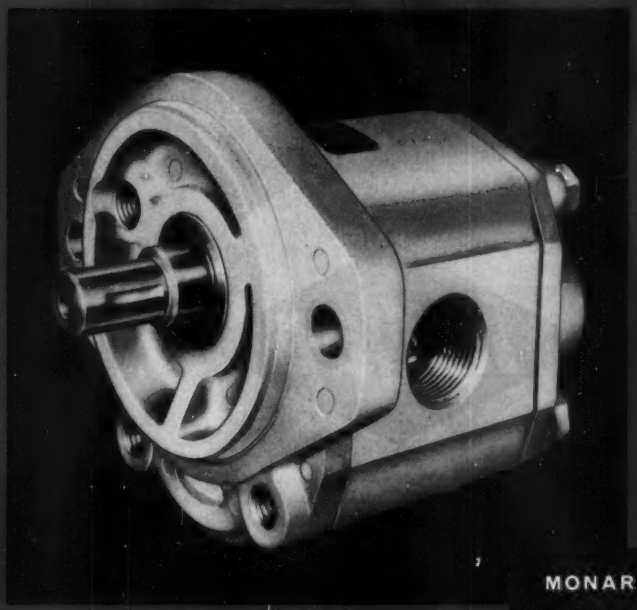
**NORTHEASTERN REGION**
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**NEW HAMPSHIRE** BALL BEARINGS, INC.
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Circle 462 on Page 19

From WOOSTER Engineering...

# NEW HIGH PERFORMANCE B-W HYDRAULIC GEAR PUMPS FOR INDUSTRY

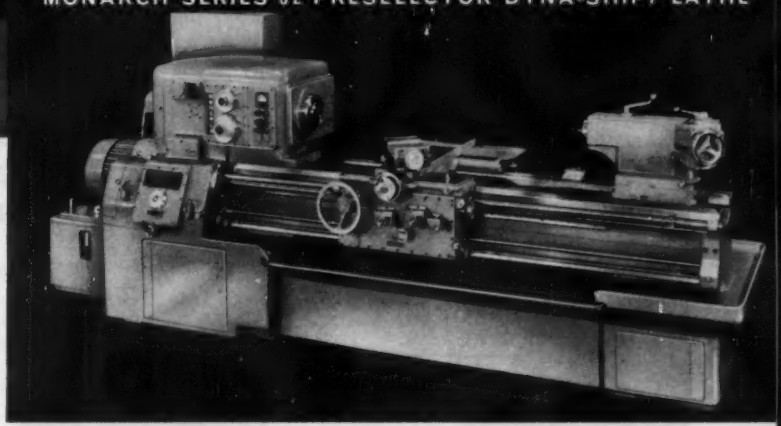


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- Higher Performance
- AT FAR LESS COST!

**P-2 SERIES**—Displaces 0.2 to 0.9 cu. in.—5 speeds to 4000 RPM—Pressure 2000 PSI

*(Available also in other capacities)*

MONARCH SERIES 62 PRESELECTOR DYNA-SHIFT LATHE



## The "Headstock That Thinks" Relies on a BORG-WARNER HYDRAULIC GEAR PUMP

A small B-W pump by Wooster, supplying mist lubrication to the intricate moving parts of the Monarch Series 62 Preselector Dyna-Shift Lathe, keeps this nimble mechanical brain in "calculating" condition. It also supplies power for shifting and clutch operation.

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***Another Demonstration of the Reliability and Adaptability of a BORG-WARNER Product—all at a Greatly Reduced Cost!***

# WOOSTER DIVISION

**BORG-WARNER CORPORATION, WOOSTER, OHIO**

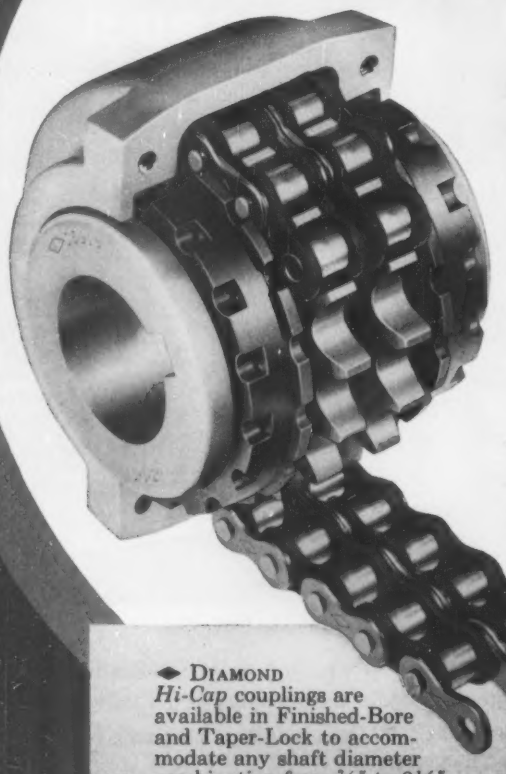
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Circle 463 on Page 19

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# DIAMOND *hi-Cap* *™



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# Why metals corrode...and how you can prevent it

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide. Six forms of corrosion which can attack the equipment you design are:

1. General tarnishing or rusting with occasional perforations in highly affected areas.

2. Highly localized attack by pitting.

3. Cracking induced by a combination of stress and corrosion.

4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.

5. Corrosion of one of an alloy's constituents leaving a weak residue.

6. Corrosion near the junction of two different metals.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

**The electrolyte** in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

**The plates of the battery** correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

**Briefly then, for corrosion to occur,** there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

## CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

**When you plan against galvanic corrosion** it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

**GALVANIC SERIES TABLE**

Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron, Cast Iron
•
Chromium-iron (active)
•
Ni-Resist
•
18-8 Stainless (active)
18-8-3 Stainless (active)
•
Lead-tin solders
Lead, Tin
•
Nickel *(active)
Inconel (active)
•
Brasses, Copper, Bronzes
Copper-nickel alloys, Monel*
•
Silver solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
18-8 Stainless (passive)
18-8-3 Stainless (passive)
•
Silver
•
Graphite, Gold, Platinum

## HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

**When you plan against local action,** remember that the corrosion process is galvanic: Electrons move from one point in the metal to another. One of the easiest ways to prevent local action is to use a metal with little or no impurity. When alloys are involved, make sure the constituents are closely listed in the galvanic series table. Local action may also be stopped by the use of protective coatings, which shield the metal from the corrosive media. Environment must also be considered, for its nature may be an important factor in either promoting or restricting corrosion.

## TECHNICAL ASSISTANCE

As you can see, many factors are involved in both local and galvanic action. That's why it's best to bring your metal problem to Inco's Corrosion Engineering Service. Available data will be furnished wherever possible . . . tests will be made where needed. Inco's Corrosion Engineering Service will be glad to apply principles of corrosion control to your specific problem.

## LITERATURE

The publications listed below will provide more detailed information on how you can combat corrosion by using nickel-containing metals.

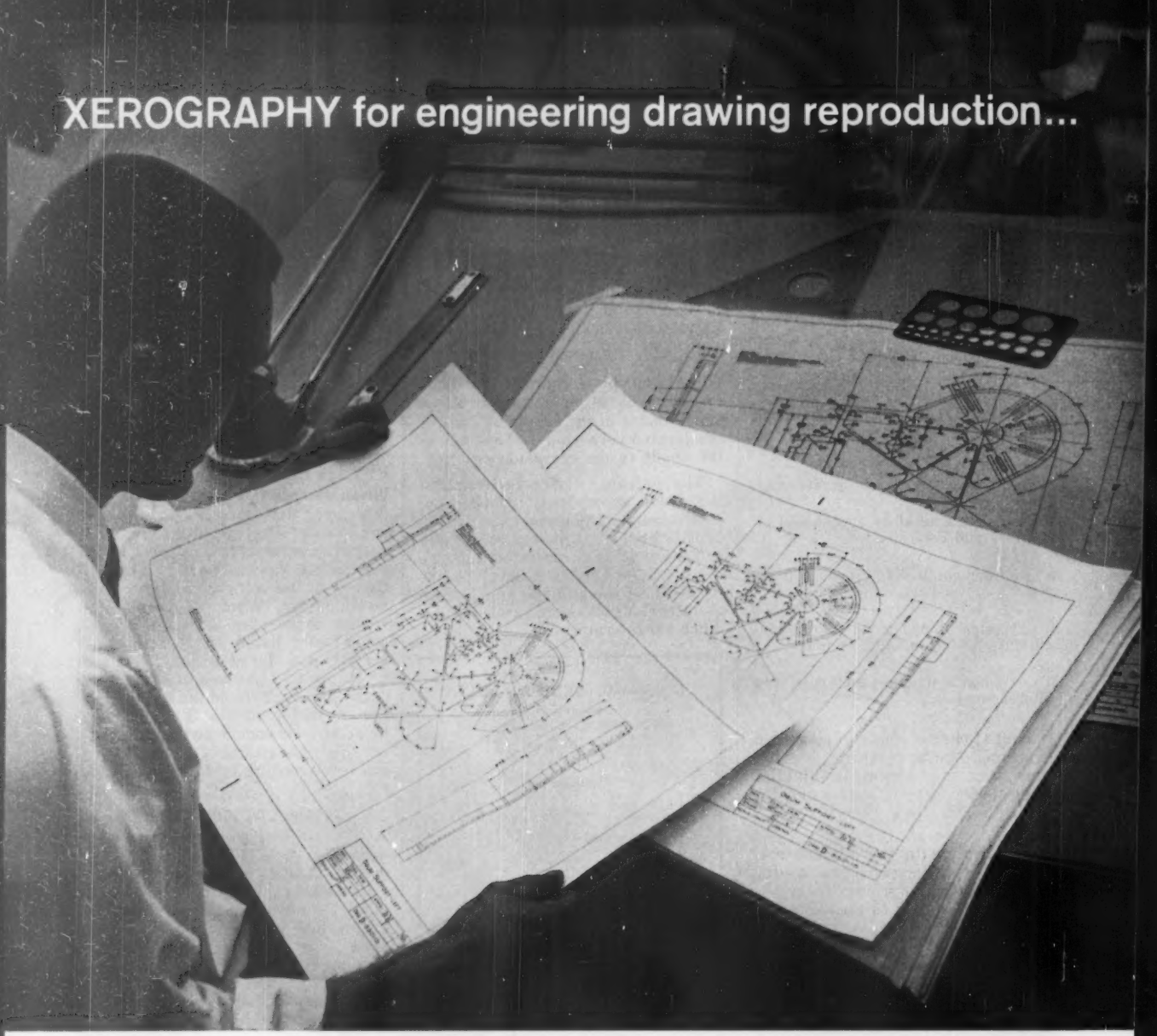
| Publication Number | Name |
|---|---|
| A232 | Corrosion Problems in Nuclear Reactor Power Stations |
| A59 | Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels |
| A62 | A Theory of the Mechanism of Rusting of Low-Alloy Steel in the Atmosphere |
| A137 | Corrosion by Some Organic Acids and Related Compounds |
| A144 | Some Observations of the Potentials of Stainless Steels in Flowing Sea Water |

A complete list of the 187 Inco publications and technical bulletins on nickel-containing metals can be obtained by writing for "List A", to:

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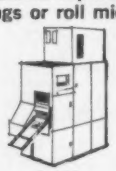
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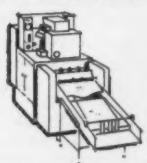


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**Volume reproduction from original drawings or roll microfilm:** Just push a button on the XeroX Copyflo® Continuous Printer for sharp, dry, ready-to-use prints (on ordinary paper, vellum or offset paper masters up to 11" wide). Prints are made at the rate of 20' a minute. Copyflo printers enlarge, reduce or copy size-to-size from original drawings or roll microfilm (16 or 35mm).



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**GET ALL THE FACTS! Send for Booklet EDX today. Write: HALOID XEROX INC., 60-115X Haloid St., Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities. Overseas: Rank-Xerox Ltd., London.**

**HALOID XEROX®**

Circle 465 on Page 19

# 10 good reasons for choosing Dynamatic Eddy-Current Speed Control Equipment

1 Adjustable speed from AC power
2 Accurate speed control
3 Wide speed range
4 Rapid response
5 Low power loss
6 Simplified construction
7 Remote control (when desired)
8 Quiet, efficient operation
9 Low maintenance cost
10 No commutators, rings, brushes, or rotating coils



Magnapower Heavy-Duty Liquid-Cooled Coupling

Using standard alternating current as a power source, Dynamatic Eddy-Current Couplings and Drives are the answer to practically all stepless adjustable speed requirements.

A wide range of standard and special control features may be obtained from electronic or transistorized magnetic amplifier control systems. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Dynamatic Eddy-Current Equipment is available in sizes from ¼ hp Ajusto-Spede Drives to heavy-duty Magnapower Couplings rated up to 20,000 hp—and larger.

Place your speed control problems in the hands of experts. Our representatives, located in all principal cities, are fully qualified to discuss your speed control problems and suggest Dynamatic Equipment that will do the best job for you. Call Dynamatic today—there is no obligation.

EATON

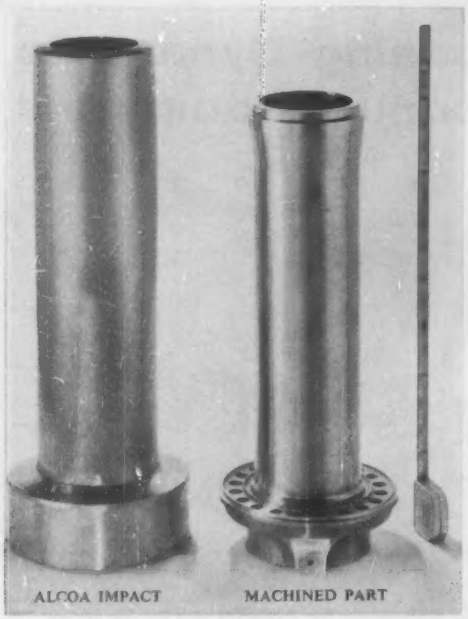
DYNAMATIC®

ORIGINATOR AND LEADING PRODUCER OF EDDY-CURRENT SPEED CONTROL EQUIPMENT

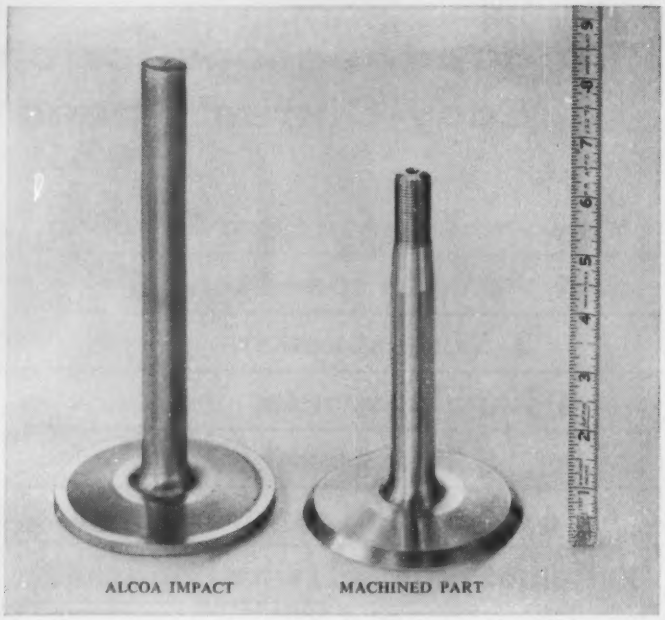
*May we Send You Illustrated Literature Describing Dynamatic Eddy-Current Equipment*

**EATON** DYNAMATIC DIVISION MANUFACTURING COMPANY
3122 FOURTEENTH AVENUE • KENOSHA, WISCONSIN


Circle 466 on Page 19




Use of an impact for this missile component provides significant savings in machining time and material cost.

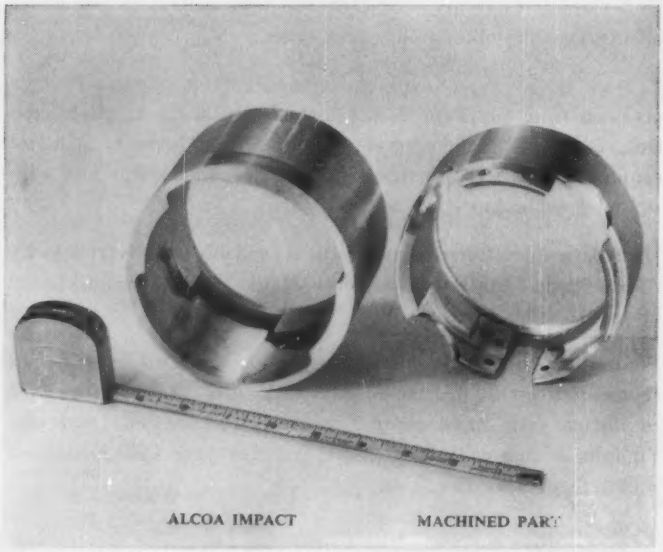



Impact eliminates prohibitive waste of stock previously encountered in machining this air compressor valve from rod stock.

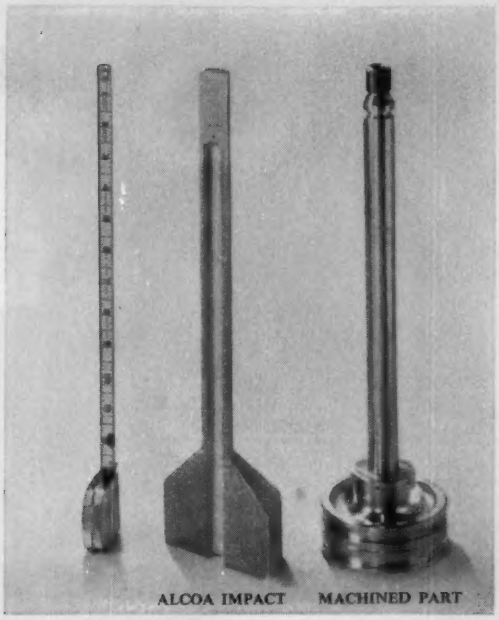
# IN IMPACTS... Alcoa



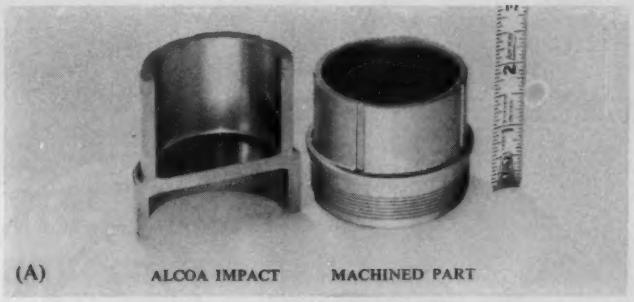

Impact replaces steel forging in which center hole had to be drilled. Cost of finished aluminum part is approximately half that of steel part.

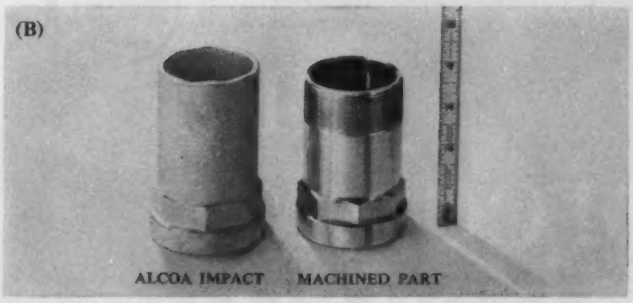



Side-wall steps and grooves in the impact reduce hogging and milling operations in this missile component.




Impact's extremely precise center hole avoids costly deep drilling while impact's outside contour saves high machining chip loss.

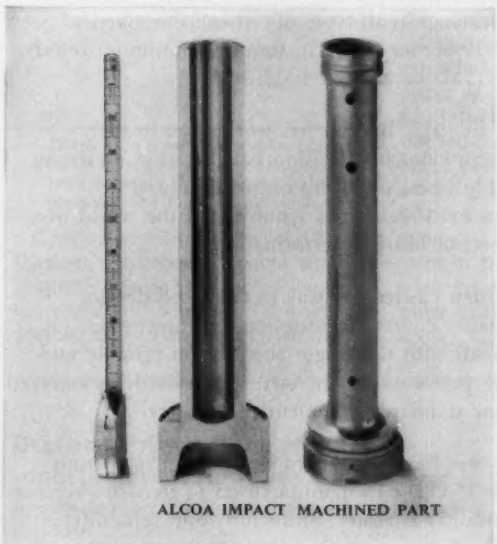



(A) Impact incorporates close-tolerance indexing grooves and keys on both ends. Saves precision milling operations and reduces machining time and costs.

(B) Impact reduces machining waste and milling of flats—unavoidable if this sleeve cable connector were machined from heavy wall tubing.

# puts the metal where you want it




Impact banishes deep drilling and wasteful machining required when machining this aircraft landing gear plunger from solid stock.

## *. . . to save time, money and metal in machining blanks*

Every impact on this page is produced quick as a wink. Every one is produced in a strong, heat-treatable alloy with good machining characteristics. Every one incorporates a costsaving design feature—a flange, step, groove, keyway, stem, rib, cavity or deep hole. Every one is made to close tolerances—as close as ±0.005 in.—without draft. Every one eliminates excessive machining waste and costly operations such as hogging, milling, broaching or deep drilling. Every one is visible proof that in impacts, Alcoa puts the metal where you want it.

The more you know about impacts, the more uses—and savings—you'll find in your own production. See for yourself. Write for *Metal in Motion*, Alcoa's new 34-page brochure on impacts. Aluminum Company of America, 905-J Alcoa Building, Pittsburgh 19, Pa.

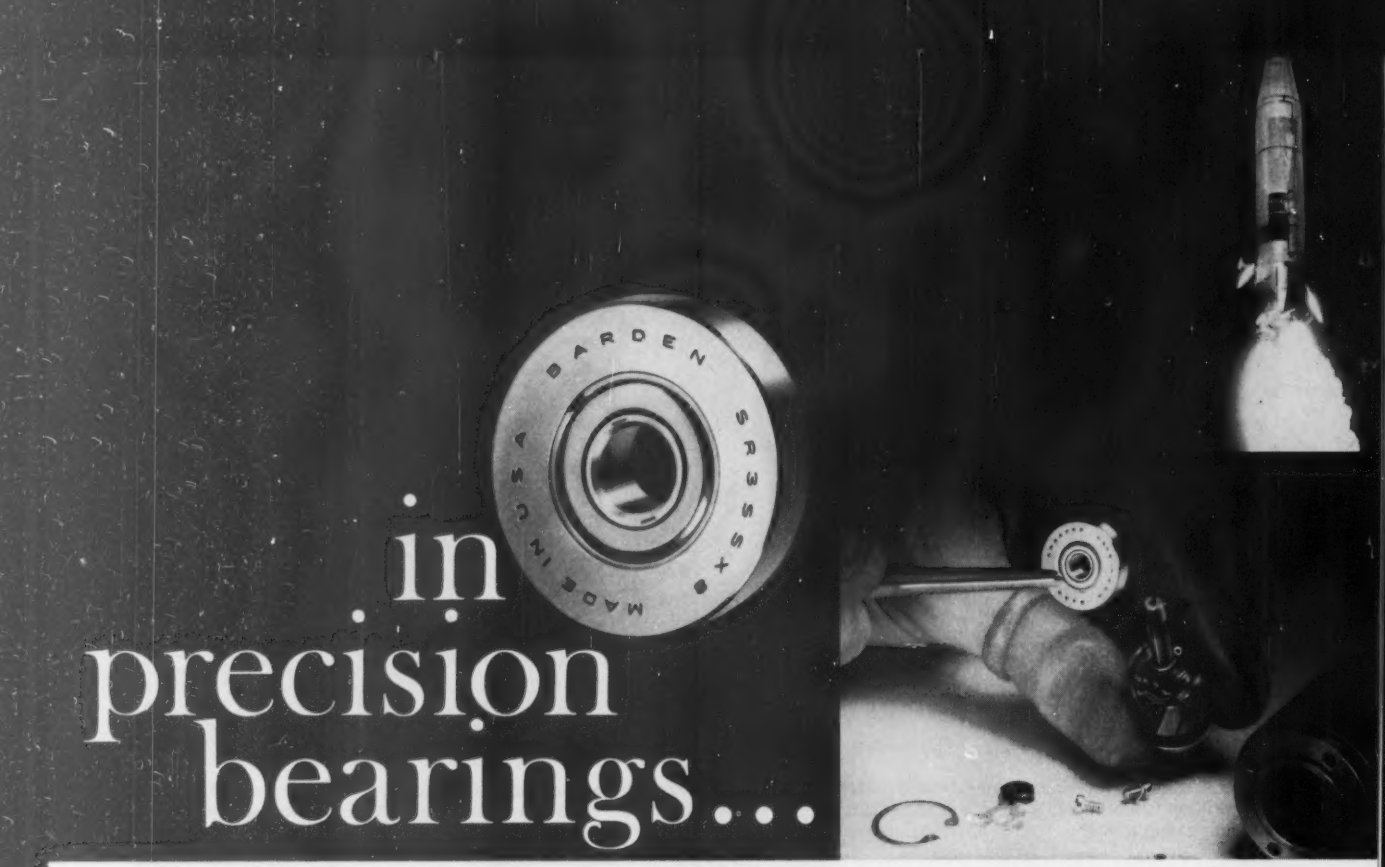
Alcoa puts the metal where you want it—
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**ALCOA ALUMINUM**

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Circle 467 on Page 19




# in precision bearings...

# PERFORMANCE IS THE PAYOFF



*In the* **BARDEN GRINDING ROOM,** *trained operators utilize highly developed skills to assure accuracy and uniformity of bearing parts—to produce the consistent quality and reliability that pays off in performance.*

**FUNCTIONAL TESTS,** *such as the Torkintegrator, developed by Barden for precise torque measurement, accurately predict precision bearing performance. Many of these Barden-pioneered tests have become industry standards.*



Precision performance is vital to the achievement of today's record-breaking scientific advances. That's why you'll find *Barden Precision* bearings in all types of critical components. Barden delivers *performance payoff* in terms of minimum rejects, reduced costs and . . . above all . . . reliability.

Since its founding in 1942, Barden has worked exclusively on design and development of precision ball bearings, devoting every effort to establish new standards of precision and quality. Today, *Barden Precision* is synonymous the world over with the highest level of bearing performance.

From the start, Barden has led the way in advanced design, production and quality control techniques and improved functional testing—all with the single objective of reliable and predictable bearing performance. In fact, many Barden-pioneered innovations are now standard in the entire industry.

Barden is a major supplier of standard bearings in sizes from .0469" bore to over 3" O.D., all manufactured to *Barden Precision* standards of dimensional accuracy, uniformity and reliability.

*for reliability...specify*

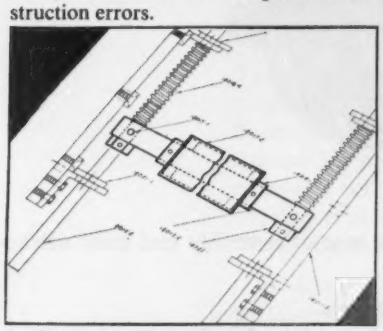
## BARDEN PRECISION BALL BEARINGS

THE BARDEN CORPORATION, 208 Park Avenue, Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, Calif.

Circle 468 on Page 19

## Ever Want Prints Emphasizing Parts of a Drawing?

Engineers, architects and many other types of technical people often want prints that separate key parts of a drawing from the rest of it, and some weird and costly techniques have been used. This is understandable because the cost of *not* getting good separation or emphasis can also be shocking. Take the case of a large West Coast engineering organization constantly involved in plant construction. They used sepia prints of floor plans to lay out the electrical work. But the lack of contrast between the plumbing shown in the sepias and the electrical layouts added required hours of careful checking and frequent revisions, even caused some expensive construction errors.



Diazo print from special-blue image intermediate produces a sharp contrast between the parts to be emphasized and those to be subdued.

That's all ancient history now! Two of Dietzgen's numerous modern drafting-printmaking aids have turned this tough old chore into a picnic. They are new drafting media (one a polyester film and the other a vellum) diazo sensitized to produce a special blue image. The reproduction of your basic drawing on either of these media is bold and clear so drafting additions can be made without confusion or error. But when you make prints from the completed intermediate, the basic part in the special blue prints faintly (clearly visible but subdued) . . . while the added drafting, even in pencil, prints strong and bold. The results are perfect, easily and quickly obtained, delightfully inexpensive.

## SOLVED: A COSTLY PROBLEM OF COMBINING DRAWINGS AND GRAPHS



Drafting time costing as much as $40 was used to draw a single grid . . . and draftsmen resented the tedious assignment.

A large manufacturer of automotive parts decided to plot their graphs directly on the drawings in order to end the nuisance of their being separated in handling, filing, plant interchange, etc. But this created many new problems. Tracing or drawing the grids in position proved costly, as much as $40 each in drafting time. They were rarely accurate and never uniform in character. The lines often smudged and usually reproduced poorly. The work created a morale problem because draftsmen resented the tedious assignment.

One of Dietzgen's modern drafting-printmaking aids furnished a perfect answer! It is a light-weight drafting film which is adhesive-backed and furnished printed with a stock grid. It is simply mounted in place and the grids are sharp, clean, clear and uniform, so much more accurate that fewer plotting points are needed to develop the graphs. Reproductions were so noticeably better as prints moved through other departments and associated plants that the change was investigated and quickly adopted. Much needed drafting time and capacity is saved and the reduction in costs amounts to many thousands of dollars a year.



### Drafting-Printmaking Handbook reports new techniques for solving engineering and production problems

This new 36 page handbook describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2- J-160 Eugene Dietzgen Co., Chicago 14, Illinois.

**DIETZGEN**

EVERYTHING FOR DRAFTING SURVEYING & PRINTMAKING

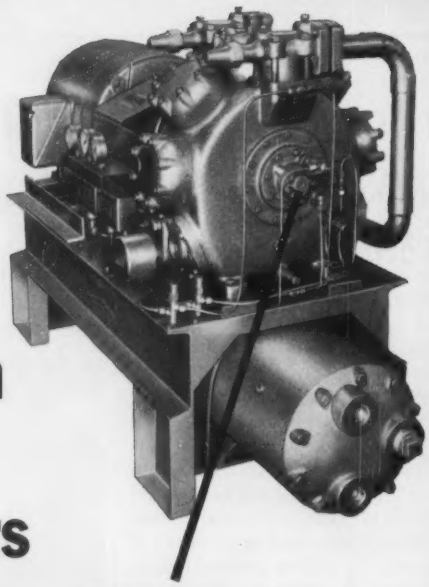


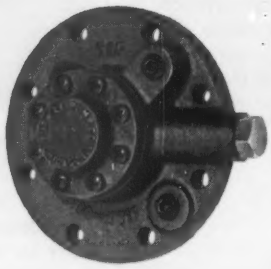
Circle 469 on Page 19

*Another pump problem . . . solved by* **TUTHILL**

# TUTHILL PUMPS

## For Positive Lubrication of New Brunner Multi-Drive Compressors





The new Multi-Drive refrigerating compressors recently announced by the Brunner division of Dunham-Bush have been "engineered to insure extreme dependability, greater flexibility, maximum performance characteristics, and highest quality".

With these objectives naturally Brunner selected Tuthill lubrication pumps as an integral part of the forced feed lubricating system. Based on their long experience in working together, Brunner knew that Tuthill's engineers would propose a reliable unit which could be incorporated in their new equipment with the greatest possible ease . . . and would most closely meet the performance characteristics demanded by the application.

### Special features

The Tuthill units finally developed reflects Tuthill's proven ability to "Fit the pump to the problem". These are modifications of Tuthill's model RLV, provided in two different sizes to cover the complete range of compressors. They have Tuthill's special reversing feature . . . required in this instance since the compressors are designed to run in either direction. At the customers request, they are provided with relief valves and a specially modified shaft extension.

And a complete new housing was designed to incorporate the unit directly into the compressor for greatest possible ease of assembly and most attractive appearance.

### Over 800 models

Hundreds of industrial leaders like Dunham-Bush have learned the advantages of bringing their pump problems to Tuthill. For Tuthill offers a complete selection of over 800 standard models . . . plus extensive engineering skills and experience in adapting these standard pumps to fit the requirements of special applications. There reliability has been proven by thousands of demanding applications including lubrication, coolant hydraulic, oil burning, circulating . . . the list could go on and on.

Catalog 100 gives an overall view of Tuthill's comprehensive line. Write for your copy today . . . or better yet forward details on your application for our engineering proposal.

*Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.*

PUMPS FOR YOUR PURPOSE

**TUTHILL PUMP COMPANY**

953 East 95th Street, Chicago 19, Illinois



Circle 470 on Page 19

# CONVERSION

## ...may pay off handsomely!

**Tremendous advances in Stamping toolings and techniques have made possible the conversion to Stampings of many complex parts previously produced by casting or forging. Foremost in the development of these advances are specialist-engineers of the Stampings Division here at The Laminated Shim Company, Inc.**

**Rocker arms, for instance. Step washers. Belt pulleys. Intricately contoured units for the tractor and automotive industries. Parts like these, and many others previously cast or forged, now may be stamped . . . in production quantities with improved functional characteristics . . . with greater accuracy . . . with the reduction, even elimination, of secondary operations . . . faster . . . and at less cost.**

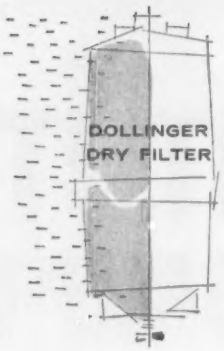
**Conversion to Stampings may open profitable, new horizons for you. Send us your prints for comments and quotes—for the price of a postage stamp you can have our experienced engineering counsel plus recommendations that may do a better job and save important dollars. No obligation, of course.**

*Stampings* **DIVISION** SINCE 1913

**THE LAMINATED SHIM COMPANY**

1209 Union St., Glenbrook, Conn.

Circle 471 on Page 19




SPECIALISTS
FOR 39 YEARS

## RESIST SYNTHETIC OIL TO 300° F

Filters for sump pumps and hydraulically operated equipment



**DOLLINGER STAYNEW SUMP FILTERS** are designed with new molded end seals of special plastic impervious to all synthetic oils, mild acids, coolants and water to 300°F. Filter medium is a mesh cloth available in either 60 or 100 screen depending on efficiency required and fluid viscosity. Exclusive radial fin design offers the greatest active filtering area in any given space. Staynew Sump Filters can be installed single or in multiple units . . . come in eight standard sizes with capacities from 5 to 100 GPM. Leading manufacturers specify Staynew Sump Filters for positive protection against dirt, sludge, rust and abrasive particles that cause expensive pump failures. Ask your local Dollinger representative for more details. Or, write for Bulletin 330-H. Dollinger Corporation, 26 Centre Park, Rochester 3, N. Y.

PROTECTOMOTOR

STAYNEW FILTERS

**DOLLINGER**

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Circle 472 on Page 19

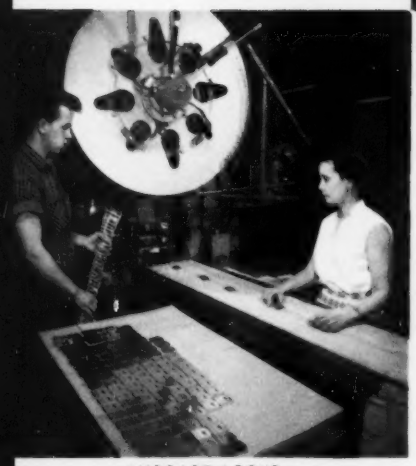
Circle 473 on Page 19→



ACCORDION DOORS

HOME MAILBOXES





LUGGAGE LOCKS



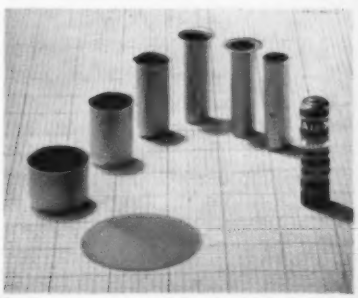
LIPSTICK BASES

CABINET HARDWARE

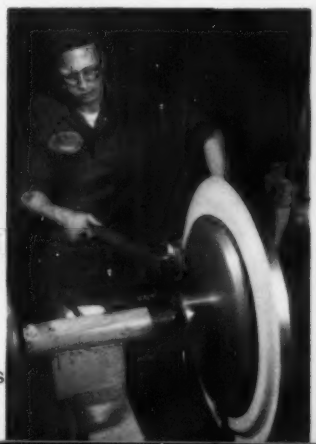


# HOW TO CUT COSTS, BOOST PRODUCT APPEAL WITH THOMAS STRIP PRE-COATED STEEL

*please turn page*



BATTERY CANS



BOILER TOPS

**Pittsburgh Steel Company**

Pittsburgh Steel Company



**Luggage Locks—Brass Coated** strip "strongly helped us compete against low-cost, brass plated imports." That's acclaim John A. Long, vice president-general manager, Long Manufacturing Co. Inc., gives Thomas Strip's brass coated steel. Long, of Petersburg, Va., is the nation's second largest luggage hardware maker. It was hard hit by foreign-made brass locks. "It was a crucial time in one of our big markets," says Sales Manager Edward C. Coleman. "We started looking for new methods and materials. Now, with new designs and using Thomas brass coated strip, we're able to fight foreign competitors." Eliminating plating and hand polishing with brass coated strip, buffed and lacquered on one side, Long trimmed 11 production steps. Result: 50% cost saving on compact-type luggage lock. Thomas Strip maintains product quality, helps Long increase die life; clear lacquer coat acts as lubricant in forming, prevents galling, and preserves product finish in inventory and in handling.

# THOMAS STRIP: TRIMS METAL COSTS, SAVES PRODUCTION STEPS, UPGRADES PRODUCTS

Metal fabricators get a head start toward material and production savings with Thomas Strip's coated steel specialties.

Combining the beauty and utility of costlier metals with the strength, economy and formability of steel, Thomas Strip also offers greater product versatility, durability, buyer appeal and design potential.

Here are benefits available to you in Thomas Strip:

• **Shortens Manufacturing Cycle**—Precoated Thomas Strip is ready to fabricate when it's delivered. Initial preparation, cleaning, buffing, final finishing are already done in many cases—you're steps ahead in production.

• **Provides Economy of Steel**—By replacing more expensive metals, but retaining their finish or functional properties, precoated Thomas Strip reduces material costs.

• **Fabricates Easily**—Electrolytically applied, hot-dipped, painted or bonded, Thomas Strip coatings endure fabrication as readily as easy-to-work base steel.

• **Cuts Plating Costs**—Serving as final finish or as base for further plating or painting, Thomas Strip eliminates or at least reduces fabricators' piece-plating expense.

• **More Pieces Per Pound**—Precision rolling and plating to extremely close tolerances give maximum yield in parts per pound.

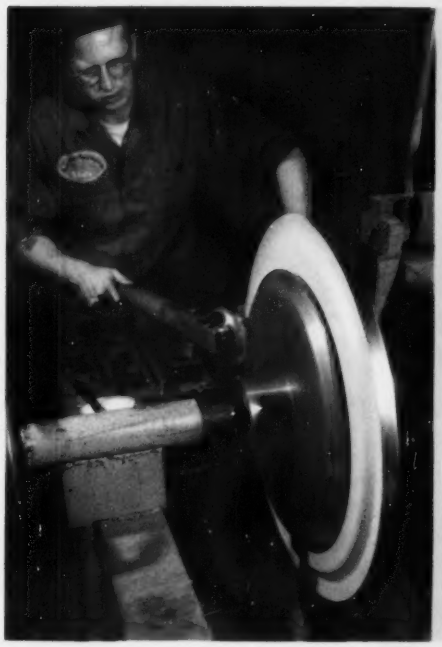
A study of the experiences of Thomas Strip users pictured on these pages should convince you of the benefits available to your product application—or to that product idea in the back of your mind. Read them.

If you need more convincing, detailed literature and samples are yours for the asking.

Better yet, contact one of the Thomas Strip District Sales Offices on the last page and ask for engineering or design help. And tell them you'd like to see our new slide film, "Bright, Modern Metals Provide Proof of the Pudding."

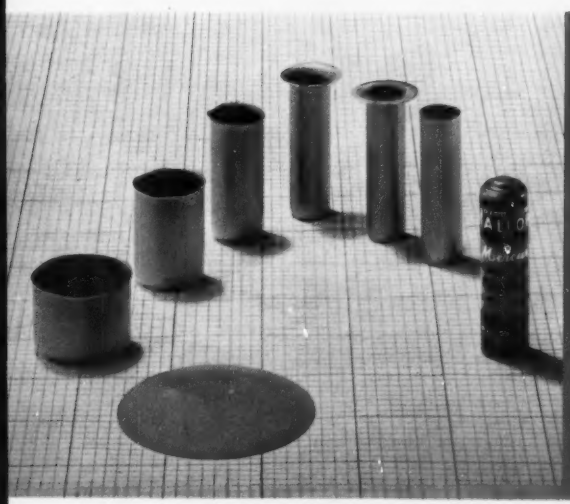
**Accordion Doors—Plastic Coated** Thomas Strip replaced hand laminating for "lead rail" of STEELITE plastic folding doors made by Clopay Corporation, Cincinnati, Ohio. Strip is roll formed with six 90° bends, ribbed and punched for rivets and door handle. Plastic endures stretching and compression. Also maintains "perfect lamination" to pass 100% inspection, says Purchasing Agent Lewis H. Washburn. Formed rails (left foreground) are assembled on rivet bench.



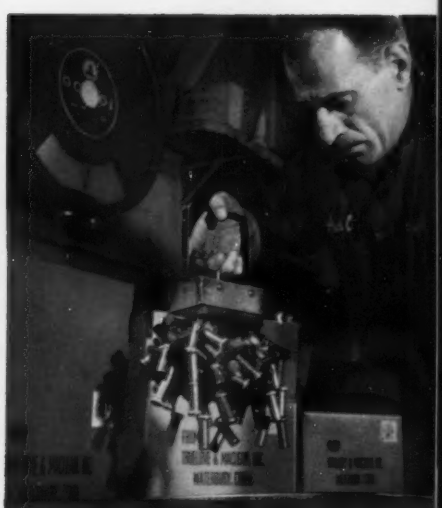




**Boiler Tops—Lacquered Strip** is spun formed by Edwards Engineering Corp., Pompton Plains, N. J., for boiler tops and top collars in packaged heating systems. Lacquer coat on Thomas Strip's aluminum-killed, drawing quality steel adheres without chipping or peeling. Edwards also uses lacquered strip to roll form back plates and front shields for baseboard units. Purchasing Agent John Bush says: "Thomas is more flexible and cooperative in giving us a quality product. We cut six steps, gained 1,500 sq. ft. of work space and eliminated fire hazards when we switched to prepainted strip. But most important, we can custom cut baseboard units to extra long lengths from prepainted coils." Edwards buys .029″ strip lacquered white on one side in 10.500″ and 5.625″ widths; 23″ width, beige lacquered on two sides.





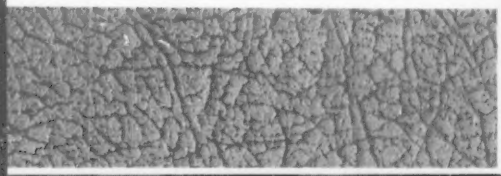


**Battery Cans—Nickel Coated** Thomas Strip is used by Cly-Del Manufacturing Co., Waterbury, Conn., to produce mercury battery cases for P. R. Mallory Co. Example: RM-502 inner can, drawn by an Eyelet process from 2¼″ by .010″ strip. AK, non-scalloping steel with .000125″ nickel coat both sides must produce can 1.776″ by .506″ O.D. without draw rings, burrs, earing, peeling or flaking. Thomas has supplied nickel coated strip to Cly-Del nearly 20 years. "Precoated strip does this job better than if we plate after forming," says Purchasing Agent Raymond W. Drufva. "There's not much competition for Thomas in nickel coated strip for close tolerance work. It's the only producer able to supply the material we need for these battery cans."



**Lipstick Bases—Copper Coated** strip means a ⅔ material cost saving for Truelove & Maclean, Inc., Waterbury, Conn., Eyelet stampings specialists. Normally a brass part, a single style of this drawn shell, is produced at rate of 5 million yearly. Firm buys AK, non-scalloping, close gage (±.0005″) copper coated Thomas Strip for ductility, die lubricating and finish plating properties. Co-owners Tom Truelove and Don Maclean say: "We wouldn't attempt some of these jobs unless the material was copper coated steel. Generally it's no harder to work steel than brass when the steel is Thomas Strip's copper coated. There's not much competition for Thomas in this line." (Top photo shows copper coated lipstick bases being packaged with magnetic lifter.)

## PATTERN ROLLED STEEL OFFERS UNLIMITED DESIGN OPPORTUNITIES





**Home Mailboxes—Pattern Design.** The Lady was looking for product appeal. She found it in pattern design sheet from Pittsburgh Steel Co. The Lady is Miss Jeanette L. Troy, director of purchases for The Randall Co. of Cincinnati, Ohio. She explains: "We were trying to find something new for our colonial style home mailboxes—a decorative effect that was different. Pittsburgh Steel's Pattern Design No. 101 gave us the appeal boost we were looking for—and without a proportionate cost boost."

Randall, a division of Textron Inc., produces the boxes for another Textron division, Wagner Manufacturing Co. of Sidney, Ohio. Industrial Engineer Wade Hartman says pattern design sheet saves 50 cents over a mailbox made of similar patterned materials. Rolled-in leather design shows no distortion in forming; permits full thickness of steel to be used in blanking, forming machines. Randall buys pattern sheets in commercial quality .024" thick and in widths 39⅝", 40¼", 42⅛".




**Cabinet Hardware—Pattern Design**—Thomas Strip's antique patterned steel helps Ajax Hardware Corporation of Los Angeles build strength and beauty into Early American cabinet hardware. President Norman D. Louis says: "Thomas Strip saves many hours by eliminating production steps. The uniformity of appearance, quality and workability of Thomas Strip's patterned steel makes it possible to match Ajax Early American cabinet hardware year after year. Production is fast because of Thomas Strip's close tolerances and formability." Ajax Hardware gives Thomas Strip's uncoated strip an electrolytic coating of rich antique copper or dull black. Photo shows packaging operation.

# THOMAS STRIP DIVISION

## Pittsburgh Steel Company

**Grant Building • Pittsburgh 30, Pennsylvania**

Steel

The STEELMARK on a product tells you it is made of steel. Look for it when you buy.

**DISTRICT SALES OFFICES**

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# NO SCORING

## ...after 25,000,000 cycles!

**Alkon series D cylinders have exclusive nylon* piston bearings to prevent scoring, prolong cylinder wall and piston rod life.** The secret is silky smooth nylon moving along a **chrome-plated steel cylinder barrel** and stainless steel piston rod, both roller burnished to a 4 micro-inch finish. No chance for scoring. Just slick, trouble-free operation, day after day, for 25,000,000 cycles and more! More facts: the Alkon Series D cylinder is built for 250 psi air service. Available in all mounting styles . . . **3-way flush mountings at no extra cost.** Exceed toughest J.I.C. standards. All are ready for immediate delivery with or without cushions.

**The Alkon series D cylinder costs at least 25-40% less than any other comparable cylinder!**

*Alkon also manufactures compatible 4-way valves and pneumatic drill units.*



Write for **new** free 24 page catalog

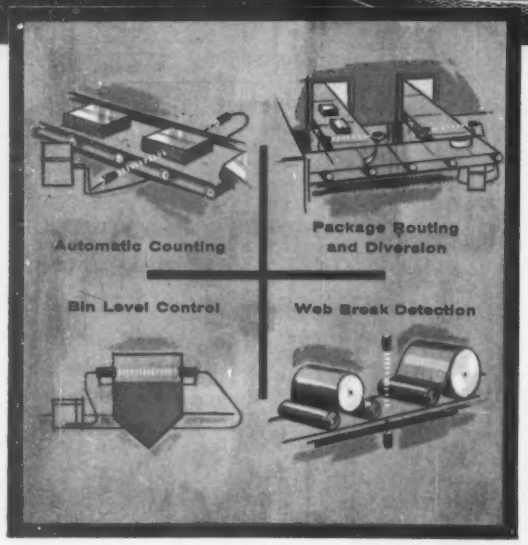
**alkon**
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*HAwthorne 7-6633*

←Circle 473 on Page 19

Circle 474 on Page 19

a new dimension in automated controls




## SONAC ULTRASONIC,

### NON-CONTACT SENSING AND SWITCHING SYSTEM

Before Sonac, sensing and switching control systems which involved breaking a beam of energy were limited by vibration, dust, smoke, steam, air contamination and too much or too little light. Sonac's ultrasonic energy "beam" is completely free of these limitations. The acoustic lens on Sonac sensors can actually be painted without affecting performance. Utilizing high frequency sound also means there are no lamps to burn out. Savings in replacement parts and maintenance time often means Sonac pays for itself. Sonac is completely transistorized, providing you with a rugged, dependable electronic circuit.

These are just a few of Sonac's many uses. Optional equipment includes reflectors for precision beam and positioning control, and coupler assemblies for use with flexible tubing for remote sensor locations. This descriptive booklet will be sent to you on request.



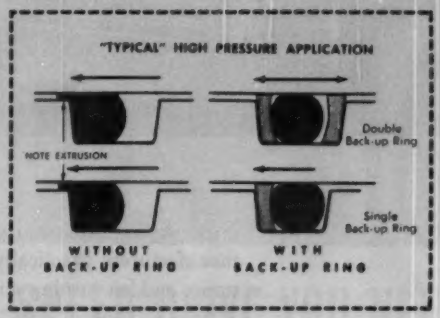

DELAVAN
Manufacturing Company
WEST DES MOINES • IOWA

# NOW – Increase O-Ring Life and Reduce Costs with...

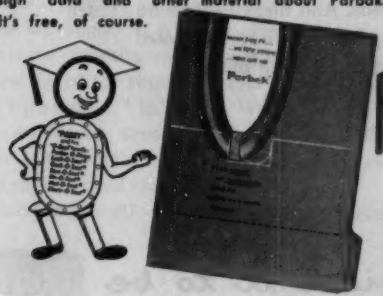
# Parbak*

## The only contoured and continuous back-up ring... simplified, easy-to-assemble, resists higher pressures!

Here's the first really new back-up ring in years . . . Test after test, both in the field and laboratory, has proved that Parbaks* greatly increase O-ring life. In addition Parbaks* improve lubrication, are easy to assemble, and resist higher pressures — *yet they actually cost less* than back-up rings for similar useage!




Why not get the facts about these unique rings, now. Send for catalog 5482 — 8 pages of design data and other material about Parbaks.* It's free, of course.



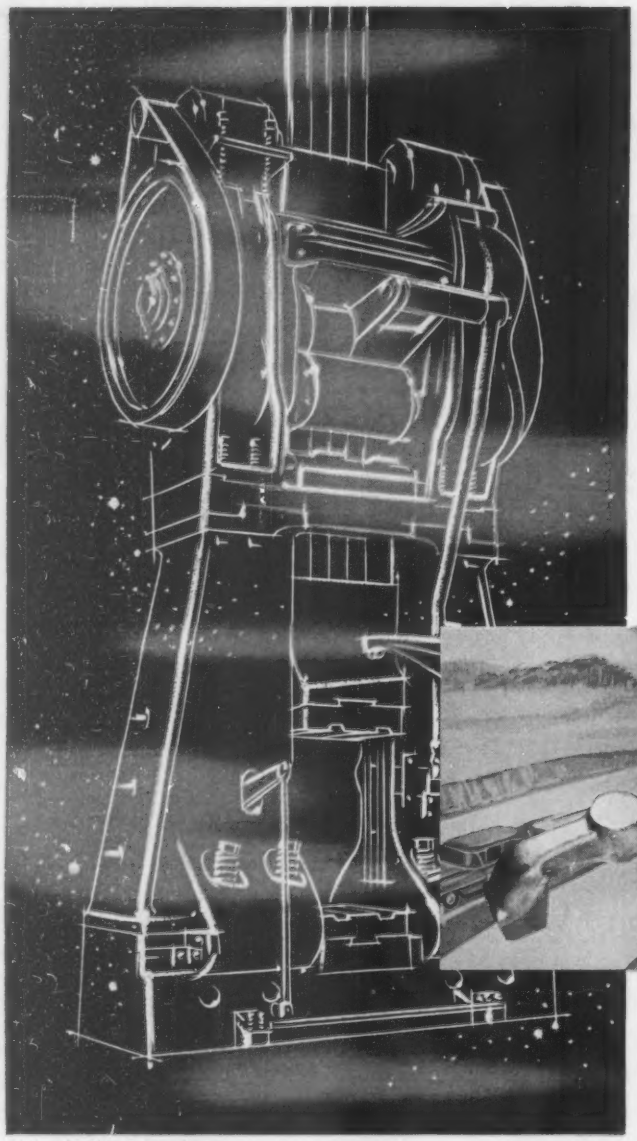

**Parker SEAL COMPANY**

Culver City, California and Cleveland, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION

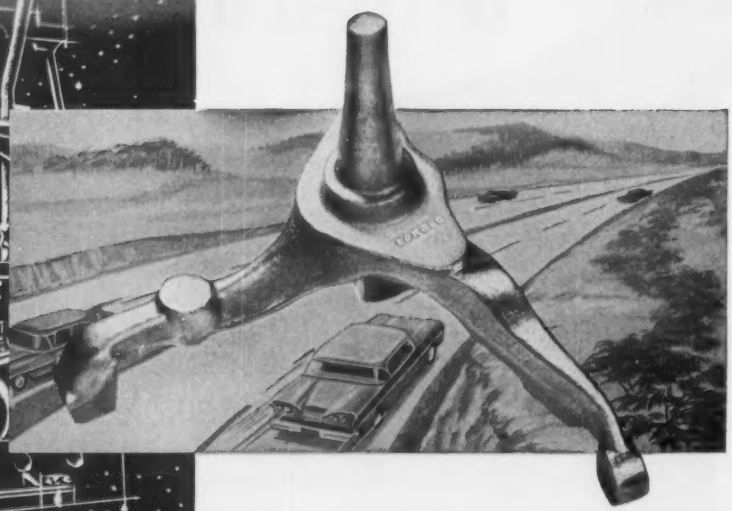
Circle 476 on Page 19

* Trade Mark



Modern board-lift forging hammer

# SHOCK-STRENGTH of steering spindle soars by designing it to be forged



By designing front-end spindles to be forged, automobile and truck manufacturers practically eliminate danger of failure of these vital parts, even under sudden turning stress that can reach thousands of foot-pounds.

Start your designs by planning to use forgings everywhere there's a high degree of stress, vibration, shock, or wear. Forged parts withstand them all better than parts made by other fabrication methods. And forgings have no hidden voids to be uncovered after costly machining hours have been invested . . . the hammer blows or high pressures of the forging process compact the *better* forging metal, make it *even better.*

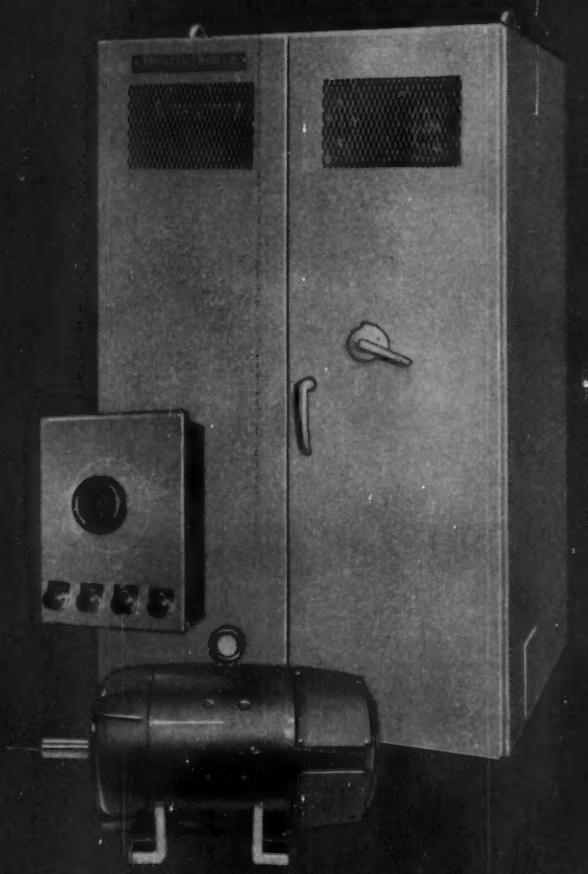
Write for literature on the design, specification, and procurement of forgings.

**When it's a vital part, design it to be** FORGED

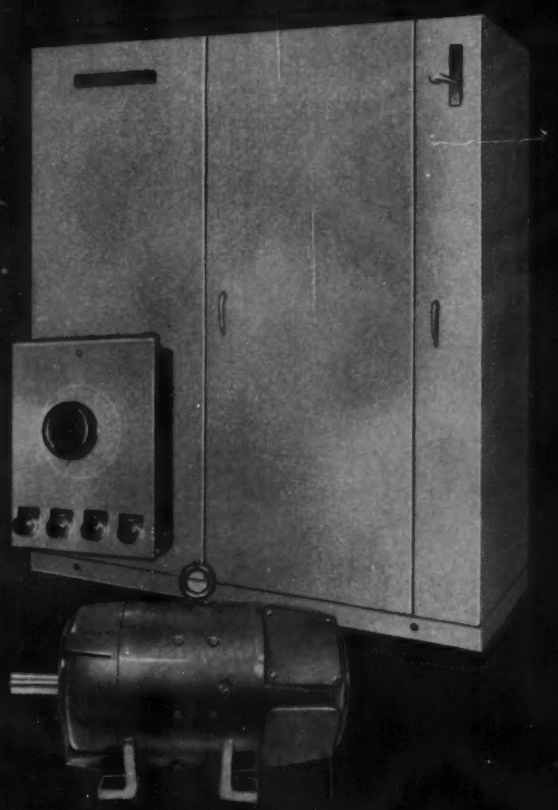
Drop Forging Association • Cleveland 13, Ohio

*Names of sponsoring companies on request to this magazine*

# static-powered or motor-generator



Static-Powered model utilizes magnetic amplifier principle to replace conventional motor-generator set. There are no moving parts to weaken from wear. New forced-filtered air ventilation system reduces floor space required . . . simplifies installation.



Motor-Generator model, newly redesigned, features new cabinet, silicone-insulated d-c motor, new electronic regulators which simplify maintenance and positive-pressure ventilation for longer, trouble-free operating life.

## WESTINGHOUSE HAS THE ADJUSTABLE-SPEED DRIVE YOU NEED!

When you need smooth, stepless adjustable speed, look to the complete line of new Westinghouse AV adjustable-speed drives . . . available in both static-powered and motor-generator models . . . whichever is best suited for your particular application.

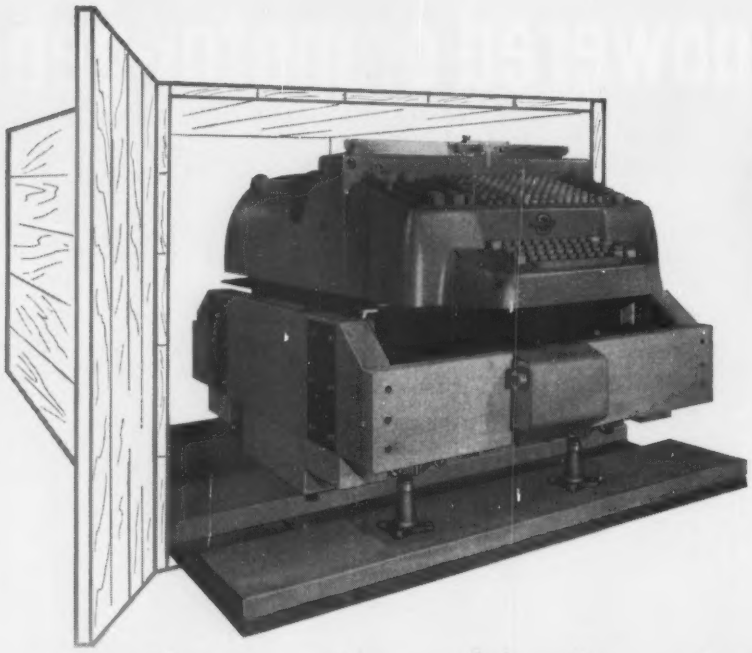
Designed for use with motors 1 to 200 hp, Westinghouse AV adjustable-speed drives provide constant torque over an 8 to 1 speed range—10 to 1 with slight modification—and are also available with constant-hp speed ranges.

All Westinghouse AV adjustable-speed drives are completely pre-engineered, assembled and factory tested. Since all components used are service-proven Westinghouse products, you are assured of the benefits of sole responsibility from one single supplier.

Ask your nearby Westinghouse sales engineer to show you how and where new AV adjustable-speed drives can help you POWER-UP for profit and savings. Or, for complete product information, write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 19, Pennsylvania. J-22147—B

Westinghouse

Circle 478 on Page 19



National

# "Lord mountings stop shipping damage, save $60,000 a year"

*reports The National Cash Register Co.*

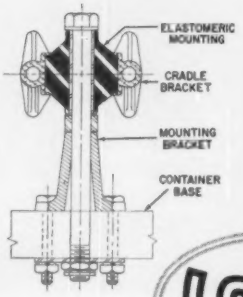
*"Packaging of National's general-purpose accounting machines for overseas shipment requires efficient, economical protection against handling damage. For several years we have used elastomeric mountings specially designed for us by Lord.*

*"Prior to the use of these mountings, about one machine in ten was damaged—and usually it was a broken base casting. This meant the machine had to be returned to the factory, disassembled and completely rebuilt.*

*"Adoption of Lord mountings has virtually eliminated such damage and now saves us an estimated $60,000 a year."*

Why not follow NCR's example and assure that your products arrive in factory-fresh condition—reliable, repair-free, ready to use. This can save you dollars and customers!

Lord capabilities in engineered shipping protection include complete facilities for testing and production of elastomeric mountings . . . plus a custom design service available through the nearest Field Engineering Office or the Home Office, Erie, Pa.




Lord elastomeric mountings protect National Class 31 accounting machines against damaging drops, impacts and vibration during overseas shipment.

LORD®

**Engineered Shipping Protection offers:**

**reliability**—custom-designed flexible suspensions give maximum protection against damaging vibration and repeated shock.

**economy**—through smaller, lighter containers . . . faster packaging . . . no premium rates for special handling . . . reduced cost for repair or replacement of damaged units.

**simplicity**—compact, one-piece elastomeric mountings are lightweight, easy-to-install, reusable.

**cleanliness**—no loose or crumbly materials to foul or contaminate products.

**broad temperature operation**—from −65° to +165° F. when required.

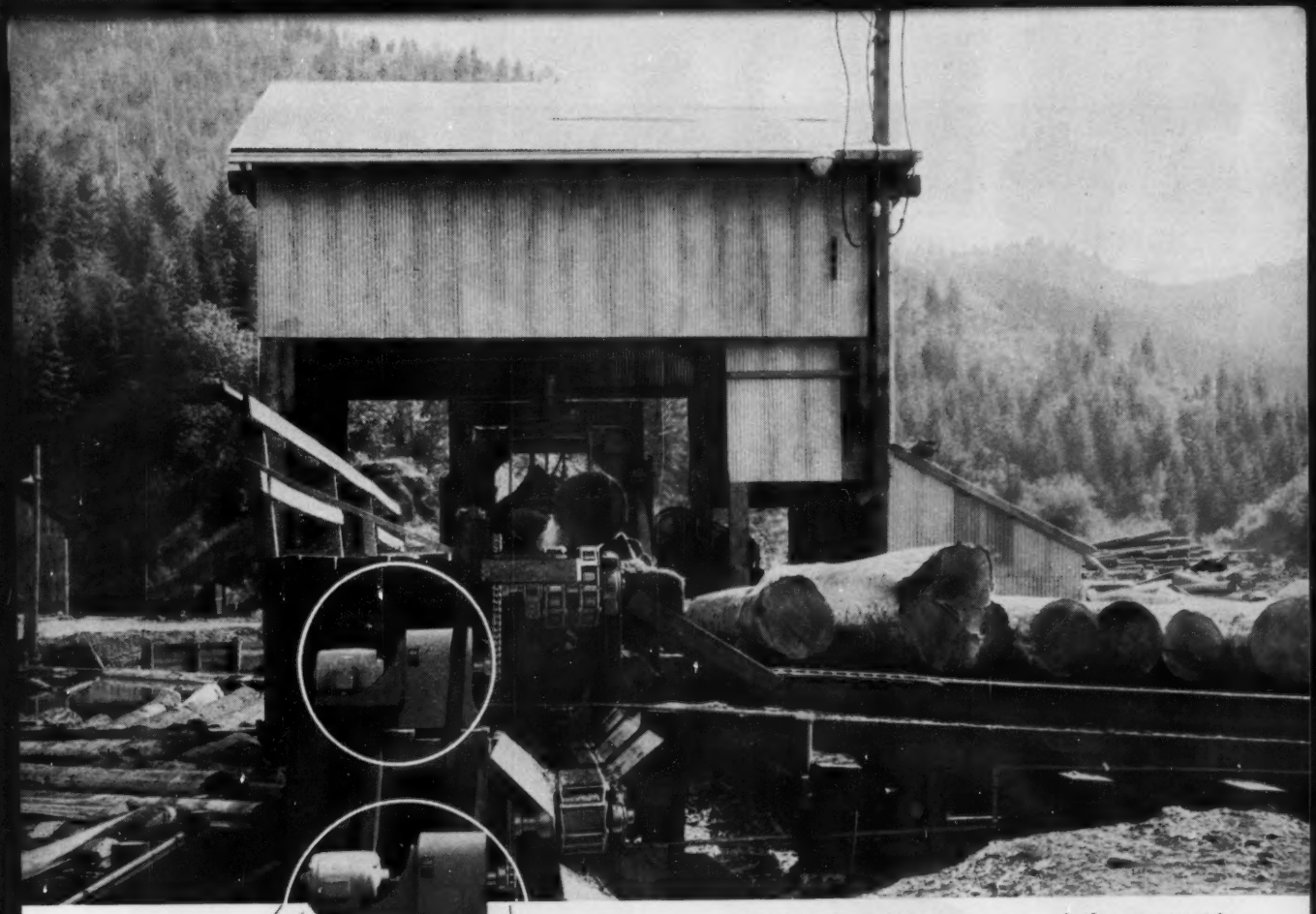
**versatility**—ideal for many types of commercial or military products, disposable or reusable containers, shipping frames, handling dollies.

FIELD ENGINEERING OFFICES

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"In Canada—Railway & Power Engineering Corporation Limited"

**LORD MANUFACTURING COMPANY • ERIE, PA.**



FALK Motoreducers driving log conveyor and refuse conveyor at the modern mill of The Bohemia Lumber Company, Culp Creek, Oregon.

# FALK *all-steel* Motoreducers give you longer service life

Whether your load conditions are normal or heavy, the extra rigidity of all-steel construction (more than twice that of cast iron) maintains better alignment of revolving elements under load...a vital factor in prolonging the service life of gears and bearings.

And if your installations are subject to shock loads, or accidental external impacts, you're way ahead when you install Falk All-Steel Motoreducers. These rugged units do not destroy themselves by tearing off their feet under jamming overloads, nor are their housings subject to cracks which both dissipate the vital lubricant supply and allow revolving elements to get out of alignment.

All-steel construction is one of the built-in extras that you get in Falk Motoreducers. Others include: (1) inherently stronger gear teeth (by AGMA standards), thanks to exclusive Falk extra-depth, high pressure angle helical gears; (2) maximum mechanical efficiency (98½% per gear mesh, under full load); (3) your choice of standard units (horizontal, vertical or right angle) to fit your precise requirements.

**HORSEPOWER RANGE: to 75 hp . . . STANDARD OUTPUT SPEEDS: 780 rpm (high) to 1.2 rpm (low).**

Prompt delivery from distributor stocks, or from warehouse or factory. Ask your Falk Representative or Authorized Falk Distributor for ***Bulletin 3100.***

**THE FALK CORPORATION, MILWAUKEE 1, WIS.**

*MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS*

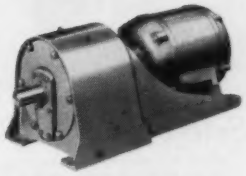
**Representatives and Distributors in most principal cities**

*Circle 480 on Page 19*

**FALK**

...a good name in industry

**Take your choice of all-steel drives when you specify Falk**



**THE FALK ALL-MOTOR MOTOREDUCER**
**...the original All-Motor unit**



**THE ALL-STEEL FALK SHAFT MOUNTED DRIVE**

**Torque ratings to 44,000 lb-in at low speed shaft. Also available in flange-mount design.**

FALK and ALL-MOTOR are Registered Trademarks.




*Select from full lines to operate and control a single OEM product ... or a plant's entire production line!*

Schrader means quality ... in complete lines of double-acting and single-acting cylinders in a variety of sizes ... including JIC and miniature cylinders. Schrader Air Cylinders ... as well as complete lines of Valves and Accessories ... are at work on many OEM products and in thousands of plants performing countless jobs. Your Schrader Distributor is fully stocked ... staffed with experts to help you solve any air circuitry problem.




The complete range of sizes and types of air circuitry products is stocked and cataloged by your Schrader distributor. Consult the yellow pages or write Schrader.

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QUALITY AIR CONTROL PRODUCTS

Circle 480 on Page 19



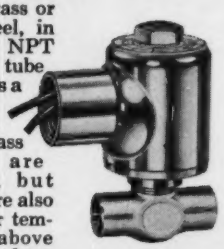
# HOKE Flow Sheet [1]

HOKE REPORTS ON FLUID CONTROL

## A VALVE NAMED "DESIRE"

With apologies to Tennessee Williams, we really have produced a Solenoid Valve line based on *your* desires. We surveyed all the solenoid valve users we could find to determine what *you* wanted. The result is Hoke's "User Designed" Series 90 and 95, two-way and three-way, direct-acting solenoid valve line.

Thanks to you, we have much to brag about. Here's what we have been saying about these new valves: lightest weight – smallest size – no-hum operation – lowest temperature rise – lowest power consumption – stainless steel plunger – silver AC shading coils – easiest installation – packless construction – 360° rotatable housing – operates in any position.



We make them of forged brass or stainless steel, in ⅛" and ¼" NPT size or JIC tube ends. There's a variety of AC and DC voltages. Class "A" coils are standard, but Class "H" are also available for temperatures above 212°F. For those with high insurance rates, we can supply explosion proof coil housings.

Now that we've bragged a bit, we must also apologize for our premature enthusiasm. We were so excited about this product that we stirred up a hornet's nest of interest before we were ready to deliver in quantity. Shipments were slow at the start, but now we can have any reasonable quantity of these "desirable" solenoid valves "on-stream" in your plant when you want them.

There's only one way to get conclusive performance proof – buy a valve. Ask for Bulletin SV-1159.

## What Goes With What?

This is a question engineers and chemists are constantly asking each other. Not that we want to do away with this healthy interplay at the water cooler, but we have put together a slide rule that answers all these questions. It lists 22 metals and materials and their degree of resistance to 247 corrosive agents.



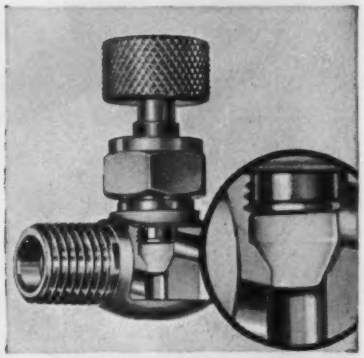

**Got yours? Write now while there are a few (thousand) left.**

## HOKE'S NEW PLASTIC STEM TIPS END CHRONIC FAILURE PROBLEM

Galling and scoring valve seats plagued valve users and manufacturers for years, until somebody thought of using plastic stem points. This idea worked well at low pressures, but when the pressure increased – poof! – the valve blew its tip. Up to now, this problem had continued to bother valve makers.

Fortunately, a die-hard Hoke engineer insisted he could put a permanent plastic tip on a high pressure valve. We gave him his head and he gave us a plastic-tipped valve-stem (using either Kel-F or Nylon). His unique design incorporates a crimped metal shell that grabs the plastic tip and *really* holds!

Not satisfied with this monumental accomplishment, he proceeded to tackle leak problems at the stem packing. He put an O-ring seal on the stem and compressed it with a newly-designed Nylon collar. The collar serves a dual role, for it also prevents grit and other foreign matter from chewing up the O-ring. Valves of this new design have performed successfully up to 3500 psi. Our die-hard engineer not only

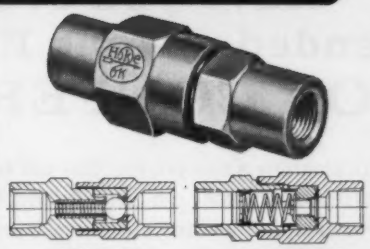


ended galling, but also seat leakage, stem leakage and wear problems – all at one swoop.

There's only one feature about this new development that worries us – since we do not expect replacements we may have designed ourselves right out of the valve business! We make these little dandies of either forged brass, bar stock or 316 Stainless, with ⅛" and ¼" male connections. Temperature limit is 400°F. For the complete story, write, wire, phone or we'll come see you.

### Hoke "TECH-SPEC"

### 570 SERIES CHECK VALVES




Designed for gas or liquid service at pressures to 5000 psi. Ball and piston types for extremely effective leak-tight closure, coupled with minimum flow resistance. Ball types in ⅛" and ¼" sizes; piston types in ⅜" and ½" sizes. Temperature limits, –40 to 200°F. Body materials are Brass or 303SS. End construction is interchangeable with any combination of inlet and outlet connections. O-ring seals are available.

**HOKE, INCORPORATED**
91 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ Plastic Stem Tips
- ☐ Solenoid Valves
- ☐ 570 Series Check Valves
- ☐ FREE Corrosion Slide Rule
- ☐ Have a salesman call

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____



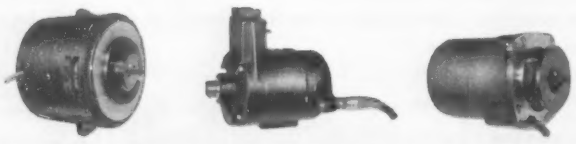
Circle 482 on Page 19



# Have you ever attended a Lamb Electric MOTOR CONFERENCE?

If you are planning a new product that will require a Special Fractional Horsepower motor . . . a Lamb District Engineer will set up a "Personalized Motor Conference", just for you.
Result: The RIGHT MOTOR produced at the most favorable cost.

**THE LAMB ELECTRIC COMPANY • KENT, OHIO**
A Division of American Machine and Metals, Inc.
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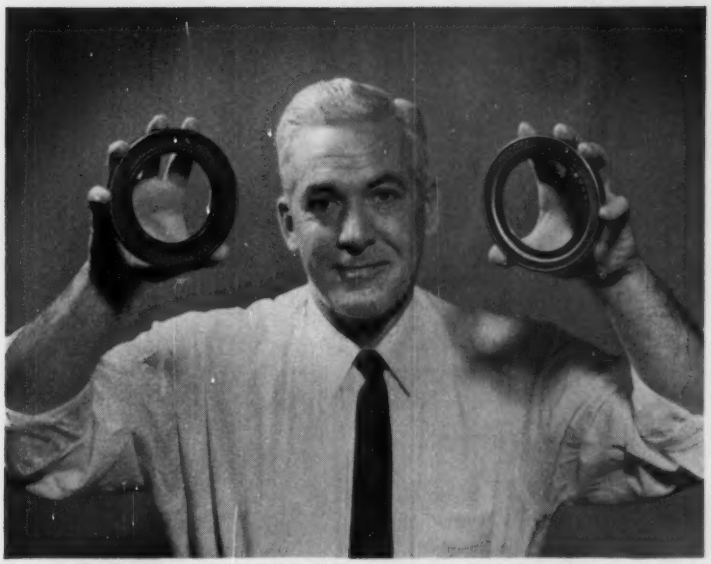
*Lamb Electric*
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

***Divisions of American Machine and Metals, Inc., New York 7, New York*** TROY LAUNDRY MACHINERY
RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
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## OIL SEALS

In Design Engineering



Proper choice of oil seal O.D. material assures longer, more positive bearing protection.

**Steel O.D. or Rubber O.D. Oil Seals?** Careful selection will assure proper performance on your application.

**Rubber should be used only for soft housing materials** such as zinc, magnesium or aluminum. In a molding process, rubber is shaped and sized by heat and pressure. These same factors exist when a seal with a rubber O.D. is applied in a steel housing . . . pressure is created by the normal press fit of the seal, heat by the location of the seal in the unit. Under these near-perfect molding conditions, the rubber O.D. seal re-forms to bore size, thus causing leakage at the bore.

**Steel,** on the other hand, should not be used in a housing made of soft material. In this case, the harder steel would tend to reshape the softer housing, causing a variety of problems.

**In seals with both rubber and steel O.D.s,** Garlock offers a complete line of high-quality KLOZURE* Oil Seals. They do a complete job of protecting bearings, sealing in vital lubrication, sealing out harmful dirt and foreign matter. During design, contact your Garlock representative for his recommendation on the best seal for your application. It costs no more to get his suggestions on the type of O.D., the seal material itself, the type of spring, and whether to use an assembled or bonded seal. Then, too, a new stocking program assures prompt delivery of KLOZURE Oil Seals when and where you need them. You can draw from over 2300 stock seals available from 180 national outlets, including one near you.

**Find out more** by calling the nearest of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for KLOZURE Catalog 30. Garlock Inc., Palmyra, N.Y.

# GARLOCK

**Canadian Div.:** Garlock of Canada Ltd.

**Order from the Garlock 2,000** . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

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Circle 484 on Page 19

# IN WAGNER GEARDRIVES . . .

# HIGH-HARDNESS GEARS

## provide greater power transmission capacity . . . longer wear life . . . greater resistance to shock



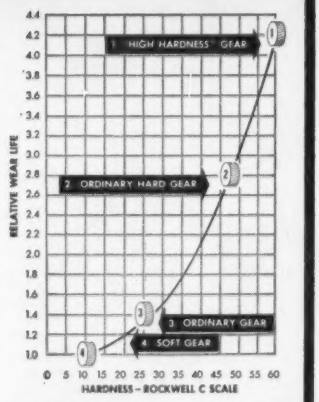
Wagner Gear Drives are built with "High Hardness" gears . . . made from forged blanks of alloy steel, carefully hardened *after* cutting. This special process develops file-hard tooth surfaces with tough, ductile tooth cores . . . maintains close-tolerance accuracy. High strength with high accuracy gives greater capacity, longer wear life than ordinary gears of the same size and weight, plus maximum resistance to shock. Table shows performance comparisons.

1. "High Hardness" gear . . . hardened *after* cutting. Precision processing permits maximum hardness while holding accuracy within extremely close tolerances.

2. Ordinary hard gear . . . hardened after hobbing and shaving. Hardness limited to maintain reasonable accuracy.

3. Ordinary gear . . . hardened before cutting. Hardening limited to maintain machinability.

4. Soft gear . . . excessive size required because of low capacity.

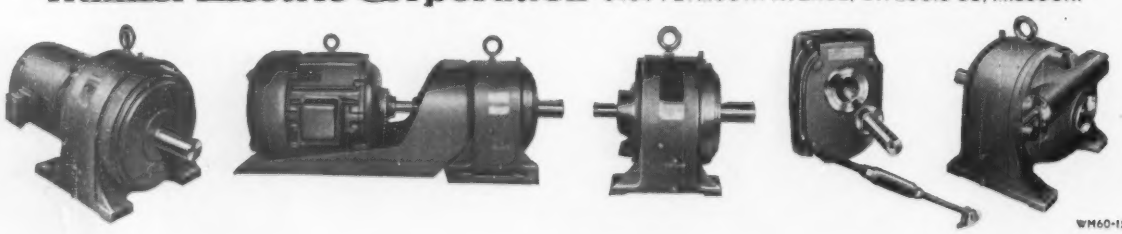



Positive, powerful, slower than motor speeds should mean one thing to you: Wagner Gearmotors. They are built to operate for years at peak efficiency. Advanced design and rugged construction with a minimum number of wearing parts, make this a certainty. Wagner Gearmotors have positive oil seals; continuous lubrication of all moving parts; extra-high capacity bearings; integral bearing housings; and rigid pyramid-mounted cast housings. Extra capacity bearings give them high overhung load ratings, too.

Wagner makes both integral-type and all-motor gearmotors, speed reducers and shaft-mounted speed reducers. They're available in single, double, triple or quadruple reductions . . . horizontal or vertical foot or flange mountings. Another important factor: prompt shipment. Standardized components permit immediate assembly of all standard sizes and types; you get equipment when you need it.

Want to know more? Call your nearby Wagner Sales Engineer; he will be glad to help you select the right drive for your application. Bulletin MU-227 gives full information.

**Wagner Electric Corporation** 6404 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI



WM60-15

. . . MICROMETER SETTING

# For Exacting Flow Control




## HANNA Flo-Set VALVES




Hydraulic pressure to 1000 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F




Air, Oil, water operation to 250 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

**OTHER HANNA VALVES**
***include solenoid, pilot, hand and foot operated types***

**FOR AIR • OIL • WATER • OTHER FLUIDS**

REGULATING cylinder speeds or controlling fluid flow of air, oil or water is so simple with Hanna Flo-Set Valves . . . you need only turn the valve body one revolution to adjust from zero to full pipe capacity. Micrometer-type graduations are numbered to indicate the percentage of pipe capacity. Once set, the position can be locked to avoid accidental change. Future resetting to a predetermined flow requires no guesswork.

Hanna Flo-Set Valves allow full flow in one direction—controlled flow in the opposite. Used in pairs, they regulate independently cylinder instroke and outstroke speeds. Hanna Flo-Set Valves assure uniform speed, smoother action and improved performance of cushioned and non-cushioned cylinders.

Valve sizes are ¼", ⅜", ½", and ¾" . . . a ¼" Jr. model, without graduations or locking collar, is available for light piping and tubing.

Whatever your problem of precision fluid control may be—you will find the best answer in Hanna Flo-Set Valves—designed, built and guaranteed by Hanna's 50 years of experience in hydraulics and pneumatics.

***WRITE FOR LITERATURE AND COMPLETE DETAILS,*** *or consult your classified telephone directory or Thomas' Register for your nearest Hanna representative.*

## Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

**1751 Elston Avenue • Chicago 22, Illinois**

# ORANGE ROLLER BEARINGS

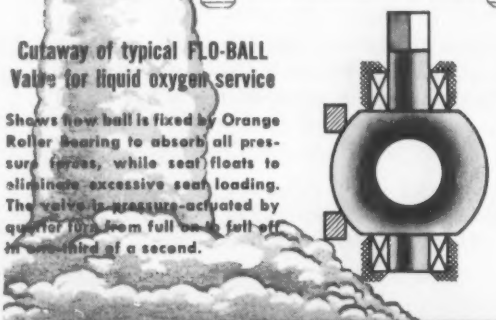
## stabilized for temperatures to −297°F.

## in WORLD'S LARGEST BALL VALVES

## used in "Nova" Moon Rocket Project



Eight 5-ton Hydromatics FLO-BALL Valves, equipped with Orange stainless steel bearings stabilized for low temperatures, are being manufactured by Hydromatics, Inc., Livingston, N. J. for liquid oxygen service in static testing of giant million-and-a-half pound thrust engines developed by Rocketdyne for the six-engine "Nova" Moon Rocket.



**Cutaway of typical FLO-BALL Valve for liquid oxygen service**

Shows how ball is fixed by Orange Roller Bearing to absorb all pressure forces, while seat floats to eliminate excessive seat loading. The valve is pressure-actuated by quarter turn from full on to full off in one-third of a second.

The use of Orange Roller Bearings in the bearing-fixed Hydromatics Flo-Ball valves assures fast-acting, low-torque operation and resistance to shock and impact, without distortion or backlash. The bearings are modified Orange Roller Bushings, consisting of a full complement of precision needle rollers, with inner and outer races.

Orange engineers have had wide experience supplying bearings for the specialized needs of missiles and rockets. We invite your inquiry and offer fullest engineering cooperation in the design and construction of roller bearings to meet your requirements.

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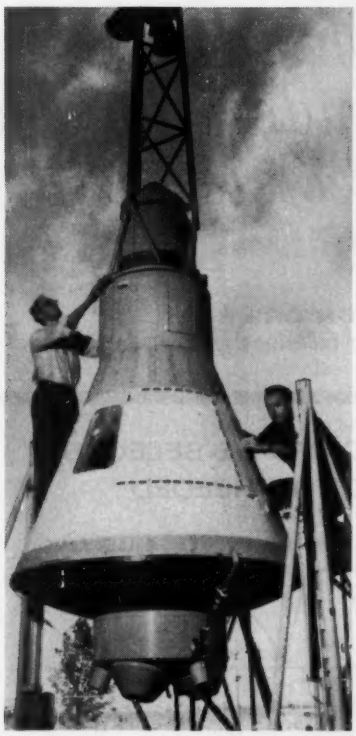
**ORANGE ROLLER BEARINGS**

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# THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING



## NO PLACE FOR AN ACROPHOBE

When first we read of the seven who are eager to blaze a route to the stars, we pondered what we thought of as man's inborn fear of great heights.

Now we learn that the first of the astronauts will have a window in his capsule, that he will peer *down* at the spinning earth and *out* at the wheeling stars.

We are producing these unique, space-going viewports for McDonnell Aircraft Corporation, prime contractor for the National Aeronautics and Space Administration's Project Mercury capsule.

The window is an excellent piece of engineering. Not just because we made it, but because it *has* to be.

It will take the slams and whams, the blistering heat, and the embrittling cold of blast-off, orbitation, re-entry, and a soak in the briny. All during this it must remain transparent, intact, and sealed tight.

There are four panes to the window. The outer two are VYCOR® 96% silica glass. The inner two are aluminosilicate glass specially tempered to phenomenal strength.

Each pane is ground and polished to the precision finish of a telescope mirror. The outermost panel curves to the contour of the capsule, so it trapezoids from an 11″ base to a 7½″ top along a 21″ height.

The glasses present a delicate balance of optical qualities, thermal shock resistance, and low weight. The last is vital when you consider that it takes about 100 gm of fuel to orbit 1 gm of payload.

So, remember, when you see the first astronaut smiling quietly, confidently from his capsule, you are looking at him through Corning glass.

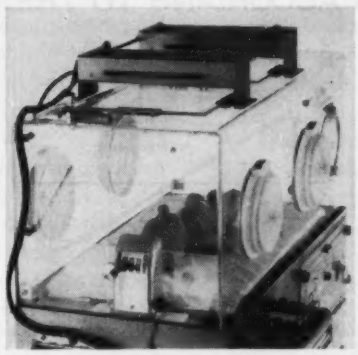
## HOW ABOUT A DEGREE IN MEDICAL ENGINEERING?

The mechanics of modern medicine are fast maturing to the point where some engineers are specializing in the building of machines like this Infant Servo-Controller for the Isolette, manufactured by Air-Shields, Inc., Hatboro, Pennsylvania.

This particular machine is used with prematurely born infants who must keep their body temperature at a constant level, but lack a well-developed thermal regulatory device.

You attach a thermistor to the babe's abdomen and let him work as his own thermostat. He automatically requests heat from infrared lamps whenever his skin temperature drops below 97°F. When things are just right again, he switches off the lamps and takes a rest, with the odds for survival more in his favor.

If you've ever tried to unbulb an infrared lamp, you know that it gives off *direct* heat as well as IR energy.

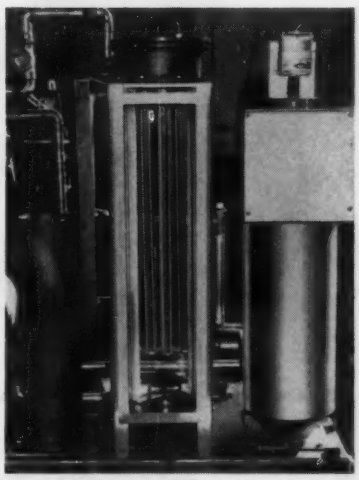


That's why there are two PYREX No. 7740 glass plates sitting on top of the plastic chamber in the picture. You can see them, if you look closely. The PYREX plates are heat resistant and will also dissipate the *direct* thermal output of the lamps. So, the plastic forgets the lamps are there.

As far as the IR energy is concerned, the PYREX plates don't exist either, so practically all the IR gets through to the baby.

The over-all relationship between IR and glass is an odd one. We can give you glass which transmits as much as 92% of the IR or a glass which transmits as little as 8% of the IR.

Happily for our product specialists, there is demand for both situations. We've prepared some bulletins on many of these IR characteristics, a copy of which you may have by sending the coupon.



## SOMETIMES GLASS IS SO OBVIOUS

Leafing our way through the 4th Annual Shirt Issue of "Cleaning Laundry World" (April 1960), we took note of an advertisement which concerned a machine which displayed a feature which we consider the soul of genius.

The machine is a dry cleaner manufactured by Detrex Chemical Industries, Inc. The feature is a glass-enclosed filter which keeps the dry-cleaning solvent cycling unpolluted. The soul of genius, to our minds, consists of intelligent manipulation of the obvious . . . in this case, an application of the first known and longest respected of the myriad properties of glass . . . to wit, its *transparency*.

When you locate such a place, it doesn't necessarily take a lot of redesigning of custom fabrication to put glass to work, either. We checked and found that Detrex, for example, simply orders standard 6″ O.D. PYREX brand Heavy Duty Tube for its filter wall.

The result is that the operator of the Detrex Cleaner can watch the filter at work. He can spot trouble while it's still potential, determine its cause exactly should it occur . . . all without any dismantling or shutdown.

Is there anything you're working on that you wish you could watch working? If there is, and you want to put glass to work, you can start by sending the coupon for a copy of Bulletin IZ-1, "Designing with Glass for Industrial, Commercial, and Consumer Applications."

CORNING MEANS RESEARCH IN GLASS

**CORNING GLASS WORKS,** 529 Crystal St., Corning, N. Y.

☐ IR Transmitting Glasses ☐ IR Reflecting Glass ☐ IZ-1

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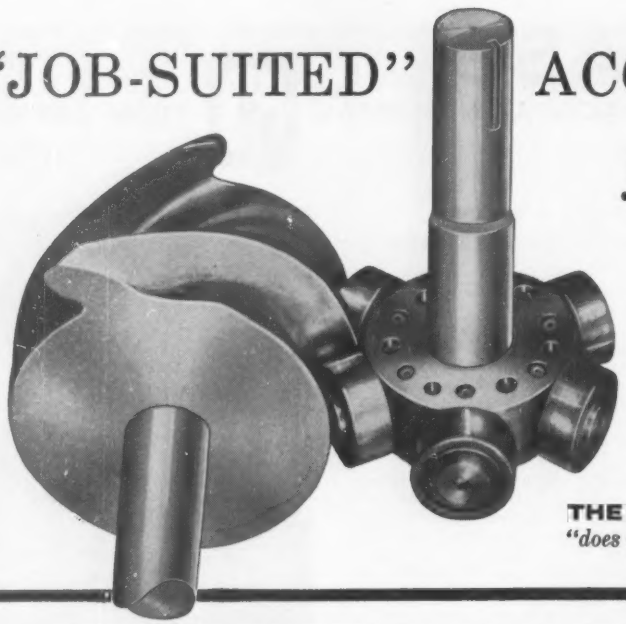
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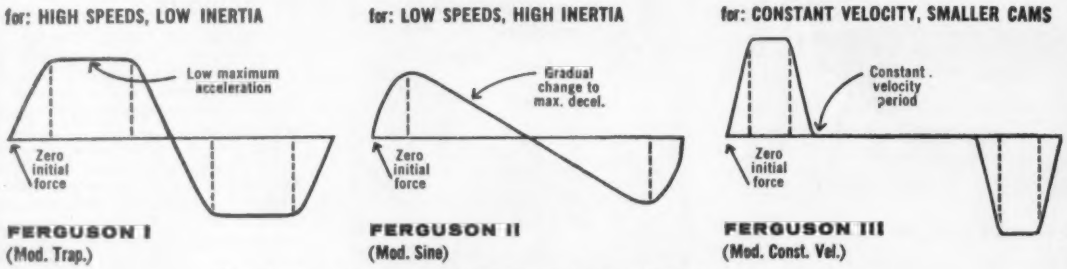
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# "JOB-SUITED" ACCELERATIONS... *for high speed indexing and precision cams*



**THE FERGUSON DRIVE**
*"does what no other indexing device can do."*

## UNIVERSAL SYSTEM OF CAM DESIGN THEORY PRE-SELECTS ACCELERATION ACCORDING TO THE MOTION NEEDED




*Three basic acceleration characteristics employed as dictated by the application*

Dynamic design becomes increasingly critical as production machinery attains higher speeds. For this reason Ferguson Machine employs the "*Universal System of Cam Design Theory*" which utilizes the type of cam and acceleration configuration calculated to provide the best combination of operating characteristics for the motion desired.

A pre-selected configuration of the plot of **Acceleration** vs. **Time** is utilized for designing indexing mechanisms, plate, barrel and groove cams and index tables. Cam problems involving unequal times for acceleration and deceleration; compensation for external forces other than inertia; resilient driven members; matching of velocities and low input torque or low impact and centrifugal force requirements are thus taken into consideration and solved.

**Movement Time** is easily proportioned between **Acceleration Time** and **Deceleration Time** and, when necessary, **Constant Velocity Time.** Established tables based on unity displacement result in design flexibility which facilitates compensation for non-dynamic forces; minimizes vibratory action by considering special characteristics of the inertia load; provides constant velocity periods, etc.

"Job-Suiting" the acceleration characteristic, the only major improvement in the practical application of cams since configuration development itself, is a service much appreciated by Ferguson's customers. You, too, are invited to benefit by the special knowledge Ferguson has accumulated in the field of cam design . . . Send us the facts about any problem related to cam and machine dynamics . . . There's no obligation.

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MACHINE DESIGN
September 15, 1960

**Guest Editorial**

# The Salaried Professional

RECENTLY a student asked me "What is this professionalism all about? How does it apply to an engineer employed at a salary?" In hashing this over we came to these preliminary conclusions:

A professional man, whether salaried with an employer or retained by a client, is actually working on a contract basis—a contract to do a job.

He is employed because of his employer's ignorance, because he has special knowledge or skill that may not be understood or even appreciated by the employer. This immediately creates a relationship of responsibility and trust.

Thus the interests of the employer must become the interests of the professional employee.

At this point my young friend objected, "We hear all this talk about trust and confidence. But engineers are being herded around, hired and fired as the government turns the contract spigot on and off. Looks like the professional man is a prize sucker."

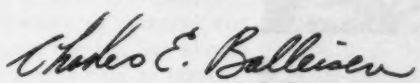
The point usually missed here is that the consultant-client or employee-employer relationship exists only after agreement has been reached on terms. From that time on, the interests of the client or employer must govern so long as he maintains his side of the agreement.

During the course of an employment, working conditions are bound to change. A professional will not quibble and scream on every occasion, for he has the intelligence to know that life never runs in a smooth and steady pattern. But he will note whether these changed conditions form a pattern different from that under which he agreed to work. And if he finally becomes convinced that a new job is the only solution, the professional cannot yet lay aside the interests of his current employer. The disgruntled employee who lets his work go to pot while still accepting full salary is certainly no professional.

In other words, the professional must always be "on the boss's side." The man who tries to do what the boss wants done may still get euchred, but at least he will be known as a man who can be trusted to deliver value for value received—and who can be recommended without reservation.

"What you are saying," concluded my student, "is that professionalism is the development of a reputation for keeping an agreement."

Isn't that a large part of it?



C. E. BALLEISEN
SOUTHERN METHODIST UNIVERSITY

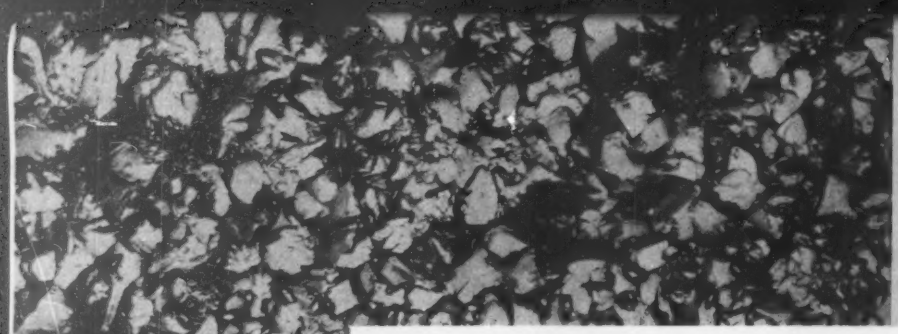


Fig. 1 — Increased surface area of a phosphate-coated part produces excellent paint-bonding characteristics. Photomicrograph shows the texture that is important in achieving mechanical bonding. (Photo, courtesy Parker Rust-Proof Co.)

*What is a Conversion Coating?*

On a metal surface, a conversion coating is the result of a chemical or electrochemical treatment that modifies a reactive metallic surface to a relatively inert, inorganic film. Chemical treatments include the phosphate, chromate, and oxide coatings. Typical of electrochemical coatings are anodic treatments for aluminum and magnesium-base alloys. This article, first in a series, covers the types of conversion coatings generally in use and discusses characteristics and applications of each coating. Part two presents considerations for product design when conversion coatings are used.

# *Selecting*

# Conversion Coatings

# *for metal surfaces*

## Part 1—Processes

**LESTER F. SPENCER**
Metallurgist
Waukesha, Wis.

CONVERSION coatings on metal surfaces play important roles in the final product design. Phosphated coatings provide corrosion resistance, good finish-bonding characteristics, or act as absorptive carriers for lubricants. Anodic coatings impart improved abrasion and wear resistance. Anodic and chromate coatings offer corrosion resistance in addition to colorful decorative appeal. Oxide coat-

ings provide moderate corrosion resistance and a variety of colors on various metals.

What are the advantages and limitations of each coating—and how are they applied?

## *Phosphate Coatings*

Phosphatizing is a treatment of a metal part with a heated solution that contains a phosphate salt or phosphoric acid and an accelerator. The converted iron or steel surface film contains zinc, manganese, iron, or a combination of these metals. Final properties of the coating are functions of size, uniformity, thickness, and density of the crystalline deposit.

**Iron Phosphate:** A deposite of iron phosphate is a comparatively light, crystalline coating with a film weight of 50 to 100 mg per sq ft. The formulation is spray applied and provides a paint-bonding surface. A detergent can be incorporated in the formulation to permit simultaneous cleaning and phosphatizing.

**Zinc-Iron Phosphate:** The weight of a zinc-iron phosphate deposit depends upon the intended function of the coating. A lightweight coating of 150 mg per sq ft is employed as a paint-base film on applications where the corrosive environment is moderate. A medium-weight coating of 100 to 700 mg per sq ft is used as a paint-base film where the corrosive environment is severe. Supplemented with a suitable lubricant, the medium-weight coating reduces friction and minimizes galling of mating surfaces. Heavyweight coatings, 1000 to 4000 mg per sq ft, provide for retention of rust-inhibiting drying or nondrying oils and waxes on steel, imparting good corrosion resistance and reducing friction.

**Manganese-Iron Phosphate:** A deposit of manganese-iron phosphate produces a heavy, black coating weighing 1000 to 4000 mg per sq ft. The coating is used on frictional surfaces to prevent galling, scoring, or seizing of parts as exemplified in the run-in of pistons, piston rings, cylinder liners, camshafts, and tappets.

Zinc surfaces, such as zinc-galvanized and electroplated steel sheet and strip, usually are phosphated prior to painting to obtain ultimate corrosion protection. This is particularly true when the interaction of the raw zinc surface and the paint vehicle could form objectionable zinc soaps that would interfere with paint bonding. A zinc-phosphate bath that provides a coating weight of 75 to 200 mg per sq ft is usually used. This treatment is also recommended for cadmium-plated steel parts that require painting.

**Amorphous Phosphate Coatings:** In contrast to the crystalline phosphate coatings employed on iron and steel, amorphous phosphate coatings are used to treat the aluminum-base alloys. These coatings are hard, apparently nonporous, nonabsorptive, and cannot be dyed or stained. A number of proprietary compounds of this type produce coating weights of 100 to 600 mg per sq ft. With these compounds, other materials such as iron, steel, and the zinc base alloys may also be successfully coated. Because of the film's nonconducting nature, spotty corrosion due to electrochemical cell activity is minimized.

**Properties of Phosphate Coatings:** An important criterion in the evaluation of a phosphate film is its ability to retain a finish or a paint, Table 1. The increase in paint retention of the phosphated sheets over that of untreated steel sheets is caused by the increased surface area, Fig. 1, obtained by phosphatizing. The increased useful life of a phosphatized and painted steel part is attributed not only to the uniformity of coverage and increased weight of an organic coating, but also to the ability of the phosphatized surface to prevent corrosion migration once corrosive attack has started.

Of equal importance is the behavior of phosphate coatings in resisting corrosion, Table 2. Corrosion

**Table 1—Paint Retention on Steel Sheets***

| Steel Sheet Condition | Paint Retained (oz per sq ft) | Increase over Untreated Steel (per cent) |
|---|---|---|
| Untreated | 0.120 | Base |
| Phosphate Coated | | |
| Roller application | 0.177 | 27.5 |
| Spray application | 0.200 | 43.9 |
| Immersion dip | 0.242 | 74.0 |

*From Reference 1. See end of article.

**Table 2—Loss in Weight Due to Corrosion***

| Coating | Coating Weight (mg per sq ft) | Weight Loss, Unoiled (mg per 100 sq cm) | Weight Loss, Unoiled (per cent†) | Weight Loss, Oiled (mg per 100 sq cm) | Weight Loss, Oiled (per cent†) |
|---|---|---|---|---|---|
| Untreated Steel | None | 21.8 | Base | 10.2 | Base |
| Zinc Phosphate (as paint base) | 364 | 13.2 | 60.6 | 2.8 | 27.5 |
| Zinc Phosphate (for corrosion protection) | 1230 | 11.5 | 52.7 | 0.9 | 8.8 |
| Manganese Phosphate | 2940 | 10.1 | 46.4 | 0.02 | 1.96 |

*From Reference 2. Data represent results of 16 months' exposure of steel panels to rural atmosphere.
†Based on untreated steel panel = 100 per cent.

resistance of the film increases appreciably with coating weight.

## *Chromate Coatings*

Chromate conversion coatings can be employed on zinc, cadmium, aluminum, copper, silver, magnesium, and alloys of these metals. Functional values of these coatings include corrosion protection, either as a final finish or as a base for an organic finish, electrical conductivity, and corrosion resistance. Chromate coatings also offer visual appeal with a variety of colors.

**Properties of Chromate Coatings:** General characteristics of a chromate coating are: 1. An amorphous film of high corrosion resistance (the nonporous deposit prevents moisture penetration to the base metal). 2. A self-healing film that is relatively soft and flexible, particularly under high-humidity conditions. 3. A film that has both a natural color and the ability to be dyed.

The natural color obtained during a chromate treatment depends upon the alloy processed, the formulation used, and processing variables such as time of immersion, bath temperature, and pH of the solution. Dye, when desired, is introduced in an immersion treatment following the chromating process. The dye colors are neither as brilliant nor as light-fast as those obtained with anodic solutions, however, and dyed components are usually limited to indoor applications.

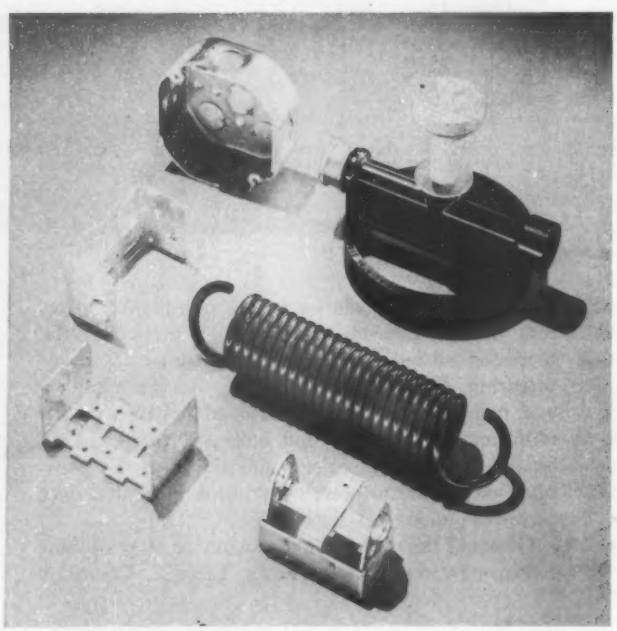
Chromate-coated parts are readily soldered or resistance-welded. Since ease of soldering is an inverse function of film thickness, it may be necessary to remove a relatively heavy film by mechanical means in the area to be soldered—particularly where a chloride fluxing agent cannot be used. The same may be true in both spot and seam welding, although the coatings often can be penetrated by the use of heavier welding currents.

**Copper, Brass, and Bronze:** Chromate coatings for copper, brass, and bronze perform the dual purpose of chemically polishing the surface and providing a thin film of moderate protective value. In salt-spray tests, 24 to 50 hr produces green corrosion products on copper, as compared to 24 hr for untreated panels. Brass has a higher resistance, ranging from 100 to 150 hr for bright, heavily-coated

**Table 3—Salt-Spray Corrosion—Chromate Coatings on Aluminum***

| Alloy | White-Corrosion Time (hr) — No Treatment | Clear Coating | Yellow or Brown Coating |
|---|---|---|---|
| 1100 (Commercially pure) | 24 | 60–300 | 250–1500 |
| 2024-T (High copper) | 24 | 40–250 | 150–1000 |
| 13 (High silicon) | 8 | 12–60 | 50–300 |

*From Reference 3.



Chromate finishes produce a variety of colors on plated parts. Spring, center, has olive-drab coating; sprinkler base, top right, has olive-drab coating, dyed black; other parts have bright metallic finish. (Photo, courtesy Allied Research Products Inc.)

panels, as compared to 24 hr for untreated panels.

These coatings are flexible and will not flake during cold-forming or bending. When bright surfaces are not required, a heavier film is used. This film serves as an excellent paint base, is electrically conductive, and can be colored with organic dyes.

**Silver:** Chromate coatings on silver provide high resistance to sulfide tarnishing and salt-spray corrosion, and cause slight decrease in surface electrical conductivity.

**Aluminum:** Many proprietary processes are available for chromate coating of aluminum and aluminum-base alloys. The natural colors obtained by these processes are primarily functions of time. For example, an immersion of 30 sec in a given solution will result in a clear film; a 2-min immersion, a yellowish film; and a 5-min immersion, a brown film. Corrosion resistance increases with immersion time, Table 3, and film color can be used as an indication of film thickness. Corrosion resistance is at a maximum on high-purity aluminum, and decreases

**Table 4—Conversion Coatings for Magnesium***

| Treatment | Type | Standards | Appearance | Remarks |
|---|---|---|---|---|
| Chrome-Pickle | Chemical | MIL-M-3171 Type 1 | Gray to yellow red | General-purpose low-cost treatment for protection during shipment and storage. Good paint base. Dimensional loss of about 0.6 mil per side occurs during treatment. |
| Seal-Chrome-Pickle | Chemical | MIL-M-3171 Type 2 | Light to dark brown | Combination of chrome-pickle and seal treatment. Improves protection over chrome-pickle. Dimensional loss of about 0.6 mil per side occurs during treatment. |
| Alkaline Dichromate | Chemical | .... | Dense black | Provides good paint base, particularly on die castings. Does not affect dimensions. Can be used on all alloys except M1A, EK30A, and EK14A. |
| Dichromate | Chemical | MIL-M-3171 Type 3 | Light to dark brown | Provides good paint base. Does not affect dimensions. Can be used on all alloys except M1A, EK30A, and EK41A. |
| Galvanic Anodize | Electrochemical | MIL-M-3171 Type 4 | Black | Used on nonaluminum-containing alloys for color, protective qualities, and as paint base. |
| Caustic Anodize | Electrochemical, low-voltage | MIL-M-3171 Type 5 | Light gray or tan | Specialty treatment, combining decorative finish, abrasion resistance, and protective value. Can be dyed. When sealed, gives good paint-base qualities. Exhibits good dielectric qualities. |
| Anodize, ac | Electrochemical, high-voltage | .... | Light gray to white | Provides excellent abrasion resistance. Cannot be dyed. Good paint base after sealing treatment. Covers flow marks on die castings. |
| Anodize† | Electrochemical, high-voltage | .... | Green | Provides excellent corrosion and abrasion resistance and paint-base surface. Dimensional increase of 0.8 to 1.0 mil per surface occurs during treatment. High-voltage bath used for rugged service conditions; reduced voltage used to produce film for moderate service conditions. |
| Manodyze§ | Electrochemical | MIL-M-3171 Type 5 | Green (dc) Black (ac) | Provides moderate abrasion and corrosion resistance. Light-gage wrought alloys processed by ac; heavy wrought and cast shapes by dc. Dimensional increase of 0.4 to 0.8 mil occurs during treatment. Coating can be dyed. Good paint-base qualities. Used on alloys containing cerium and zirconium. |
| HAE‡ | Electrochemical, high-voltage and low-voltage | MIL-C-13335 (ORD) | Brown | High-voltage coating exhibits exceptionally high hardness, good dielectric properties, and high corrosion, abrasion, and heat resistance. Used on standard alloys and on alloys containing thorium, zirconium, and rare earths. Dimensional increase of 0.3 to 1.0 mil occurs during treatment. Low-voltage coatings used for moderate environments. |

*From Reference 4. †Dow No. 17. Dow Chemical Co.
§Consolidated Vultee Aircraft Corp. ‡Western Sealant Metal Finishing Co.

with increase of alloy constituents, particularly copper and silicon.

Dimensional change of parts during processing is negligible—up to 0.01 mil. The film has sufficient flexibility to permit sharp bending without flaking. The film may also be classed as an electrical conductor with resistance varying from 2500 to 50,000 micro-ohms, depending upon coating composition and operating conditions.

**Magnesium:** Because of the activity of magnesium and magnesium-base alloys, the chromate coatings assume considerable importance in providing both paint-base and corrosion-resistant surfaces, Table 4. These coatings are produced by: 1. The chrome-pickle treatment. 2. The sealed-chrome-pickle treatment. 3. The dichromate bath. 4. The alkaline dichromate bath. 5. The galvanic anodize treatment.

**Zinc and Cadmium:** Chromate coatings are used extensively on zinc and cadmium-plated parts, zinc-galvanized products, and on zinc-base die castings. On die castings, the chromate coatings are applied either as a final finish or as a bright dip prior to electroplating the copper-nickel-chromium finish.

When the process is used on an electroplate, the minimum plate thickness for zinc is 0.2 mil, and optimum protection is obtained at a thickness of 0.7 mil. When required, these coatings can be dyed. The natural, olive-drab coating on zinc is the most wear resistant of all chromate coatings. It also provides corrosion protection superior to the bright finish, Table 5.

## *Anodic Coatings*

Anodized films are produced by electrochemical reaction. They are harder, more resistant to abrasion and corrosion, and more expensive than chromate films. Anodized films are used on aluminum and magnesium alloys both for decorative appeal and for efficiency in protecting the base metal.

**Magnesium:** Anodic treatments for magnesium, Table 4, are classified as low-voltage and high-voltage baths. High-voltage baths produce coatings 1.0 mil thick. The film is hard and refractory in nature and exhibits excellent corrosion, heat, and abrasion resistance. Low-voltage baths produce film thicknesses up to 0.8 mil. The film is softer, more flexible, and less resistant to abrasion, heat, and corrosion than that produced by the high-voltage bath.

**Aluminum:** Of the many treatments available for anodizing aluminum alloys, the sulfuric and chromate are the most widely used.

*The sulfuric-acid process,* used extensively for decorative finishes, produces a surface that is readily dyed. Permanency of color is a function of both the type of dye used and the amount of dye absorbed. Sealing is required after coloring to increase corrosion resistance and to resist further absorption. The coating, when applied to nonheat-treatable aluminum alloys, has greater hardness, abrasion resistance and corrosion resistance than the same coating on heat-treatable alloys. These properties, as well as dielectric strength, are proportional to coating thickness.

*The chromic-acid process* is limited to aluminum alloys that contain less than 5 per cent copper. Response of this surface to dyeing is similar to that of the sulfuric-acid process. As compared to the sulfuric-acid-produced film, the chromic coating is darker in color, more opaque, and generally softer, with film thickness ranging from 0.02 to 0.2 mil.

Both the sulphuric and chromic-coating processes have been displaced by the nonelectrolytic chromate treatments for paint-base surfaces due to the greater flexibility and economic advantages of the latter.

Hard anodized coatings of 1 to 5-mil thickness are particularly valuable where environment demands high resistance to erosion, abrasion, and cor-

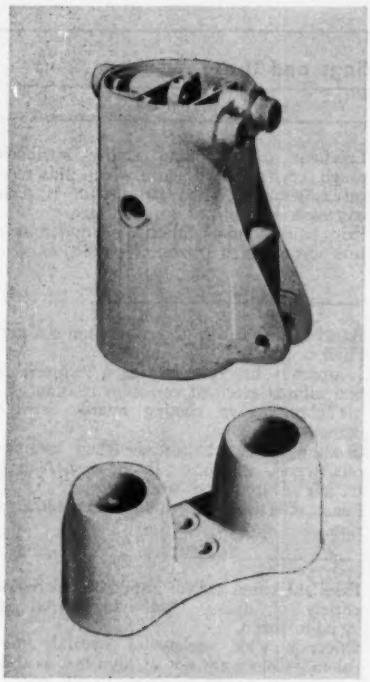
**Table 5—Salt-Spray Tests—Chromate Coatings on Zinc-Plated Steel***

| Type of Corrosion | Corrosion Time (hr) | | | |
|---|---|---|---|---|
| | No Treatment | Clear or Bluish Bright | Yellow to Bronze | Olive Drab |
| White | 8 | 24–100 | 100–200 | 100–500 |
| Red Rust | 150–400 | 250–750 | 250–1000 | 500–1500 |

*From Reference 3. Plate thickness, 0.0002 to 0.0007 in.



Moderate corrosion protection of a black-oxide surface is adequate for many steel parts. Protection is increased when coating is supplemented by oil, wax, or lacquer. (Photo courtesy Mitchell-Bradford Chemical Co.)



Amorphous phosphate film is used to provide a paint base on aluminum and zinc-base alloys, such as these food-mixer components. (Photo, courtesy Parker Rust-Proof Co.)

rosion. Typical solutions include Alumilite 225 and 226 for wrought products and Alumilite 725 and 726 for cast alloys. An allowance of 50 per cent of coating thickness must be allowed for dimensional growth.

Chromate-anodic films are also used to detect stress-produced cracks in aluminum alloys. This test is predicated on the absorption of chromic acid in the cracks during anodizing.

## *Oxide and Other Coatings*

Black oxide films on iron and steel are used in applications requiring exposure to moderate corrosive environments. If outdoor exposure is contemplated, this comparatively thin film must be supplemented with a protective coating of oil, wax, or lacquer. Luster of the coating is a function of prior surface condition of the part. A glossy finish is obtained on highly buffed surfaces; a dull finish, on etched, brushed, or sand-blasted surfaces.

The oxide film, ranging from 0.06 to 0.1 mil thick, offers several advantages: 1. Low cost. 2. Low coefficient of friction and nongalling properties when oiled or waxed. 3. Negligible dimensional change during treatment. 4. Attractive decorative effect.

When used as a base for wax, lacquer, or enamel, this highly alkaline coating must have an intermediate neutralizing dip to utilize the full protective powers of the finish coat.

Although prolonged immersion can produce a film thickness greater than 0.1 mil, it can also cause a loosely adherent deposit to form. Such a coating decreases rather than increases the potential corrosion resistance. Degree of protection also varies with

**Comparison of Properties—Electrochemical and Chemical Coatings***

| Property | Electrochemical | Chemical Conversion |
|---|---|---|
| Corrosion Resistance | Varies with process and treatment time. A treatment of 20 min in sulfuric acid or 30 min in chromic acid will produce a coating resistant to 240 hr exposure to salt spray. Scratched areas are vulnerable to corrosion. | Varies with composition and treatment time. Coatings produced after 3 to 4 min immersion will usually resist 240 hr exposure to salt spray. Some new proprietary coatings resist salt spray attack 500 to 1000 hr. Scratched areas are protected by surrounding film. |
| Color | Clear to gray. Highly decorative dye finishes can be obtained. | Clear, iridescent yellow, or brown. May be dyed, but colors are not light-fast. |
| Paint Base Properties | Good base for paint; best after chromic-acid treatment, unsealed. | Good base for paint. |
| Mechanical Properties | Coatings are hard and brittle and offer excellent resistance to abrasion. | Coatings are soft and flexible and offer poor resistance to abrasion but will not flake off in bending. |
| Electrical Properties | Insulator. | Conductor. |
| Weldability | Cannot be welded. | Most coatings can be welded by shielded arc; others can be spot welded. |
| Temperature Effect | Temperatures above 250 F can cause crazing, although this effect is not harmful to corrosion resistance. | Temperatures above 200 F reduce corrosion resistance. |

*From Reference 5

**Summary of Conversion Coatings and Uses**

| Coating | Material Coated | Remarks |
|---|---|---|
| **Paint Bonding** | | |
| Phosphate | Aluminum zinc, cadmium, iron, and steel. Sometimes used on magnesium and tin. | Excellent paint-bonding ability attributed to rough, crystalline structure which aids mechanical adhesion. When paint film is damaged, corrosion is confined to that area. |
| Chromate | Aluminum, cadmium, magnesium, and zinc. Sometimes used on copper, tin, titanium, iron, and steel. | Fair paint-bonding ability. Nonporous structure affords high corrosion protection. |
| **Corrosion Resistance** | | |
| Anodic | Aluminum and magnesium. | Rated as best within the conversion coating field. Highest cost. |
| Chromate | Aluminum, zinc, cadmium, magnesium, and copper. Sometimes used on tin, silver, iron, and steel. | Nonporous structure acts as a moisture barrier and affords excellent corrosion resistance. Soluble chromate in coating retards corrosion at damaged areas. |
| Phosphate | Aluminum, zinc, iron, and steel. Sometimes used on cadmium and tin. | Coating is most effective when treated with oils, waxes, or stains. Provides short-term protection of iron and steel. |
| Oxide and Similar | Occasionally used on zinc, copper, cadmium, aluminum, iron, and steel. | Least effective. Used for short-term protection. |
| **Decorative Effect** | | |
| Anodic | Aluminum and magnesium. Occasionally used on zinc. | Excellent when sealed. May be colored with a variety of dyes. Underlying metal imparts metallic sheen. |
| Chromate | Aluminum, cadmium, copper, magnesium, and zinc. Occasionally used on tin, iron, and steel. | Offers a wide variety of natural and dyed colors. Colors are not as light-fast as those obtained from anodic coatings. |
| Oxide and Similar | Aluminum, zinc, copper, cadmium, iron, and steel. | Produces black and blue-black coatings on zinc, cadmium, iron, and steel. A variety of colors can be obtained on copper and aluminum. |
| **Wear Resistance** | | |
| Anodic | Aluminum and magnesium. | Heavy coatings afford excellent wear and abrasion resistance. |
| Phosphate | Iron and steel. | Prevents welding between bearing surfaces under load when coating is supplemented by oil film. |
| **Cold Forming Aid** | | |
| Phosphate | Titanium, iron, and steel. | Excellent, especially when used with a lubricant to minimize metal-to-metal contact. |
| Oxide and Similar | Titanium. | Special coatings are available for this use. |

steel analysis; highest protection is realized with the low-carbon steels.

Other coatings for steel are produced by: 1. The browning process, which produces a film by treating the surface with an acidified solution followed by an oil dip. 2. The carbonia process, which produces a gunmetal finish when supplemented by an oil dip. 3. The color-temperature method, where the metal is heated and held at temperature for a short period. Colors ranging from straw to brown to blue result, depending on the temperature used. 4. A salt or sodium-hydroxide bath method, which produces a blue-black or black finish.

Copper base alloys, having a copper content of at least 65 per cent, can be given a black coating with a hot caustic-alkali bath containing strong oxidizing agents. Such a panel, protected with an oil or wax coating, will withstand over 200 hr of salt-spray exposure before a green salt appears. An untreated panel will withstand only 15 to 20 hr exposure before breakdown.

A bright, lustrous finish is obtained on a buffed surface; a dull finish, when the surface is previously brushed, etched or sand-blasted. The highest luster is obtained by coating the colored surface with a high-bodied, clear baking enamel.

The film is extremely adherent and permits considerable handling and wear. Thickness is in the range of 0.05 to 0.2 mil.

Oxide-coating processes for zinc, zinc-base alloys, electroplated zinc and cadmium, and hot-dip zinc coatings produce a film thickness of 0.04 to 0.08 mil which serve well for indoor use or for exposure to mild atmospheres. Supplementary oil, wax, or lacquer coatings increase surface life.

Oxide films for aluminum and aluminum-base alloys are used to a lesser extent. Proprietary processes include MBV, Pacz, and McColloch.

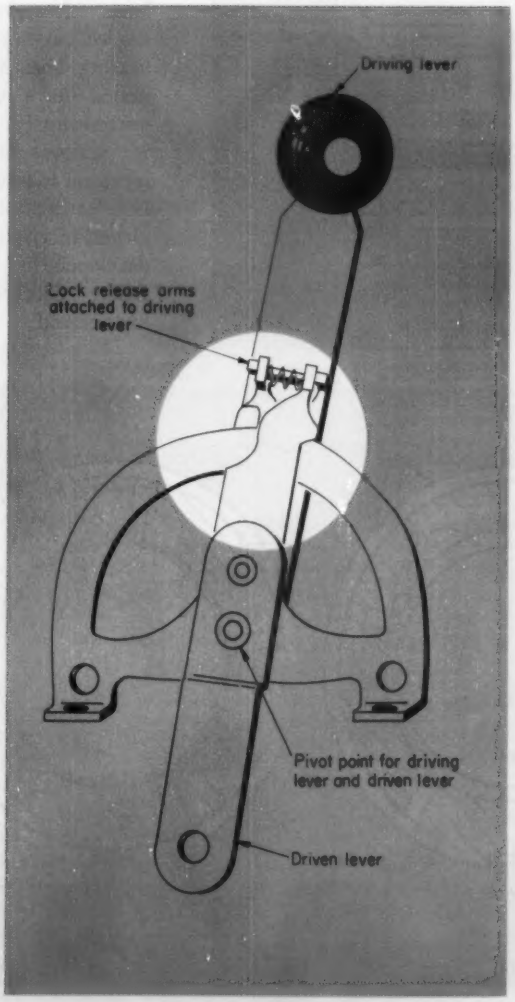
Limited work has been done on the use of conversion coatings on titanium—mainly concerned with improvement of wear resistance, prevention of galling, and as an aid in cold forming.

**Next article**, concluding this series, discusses how the use of conversion coatings affects product design.

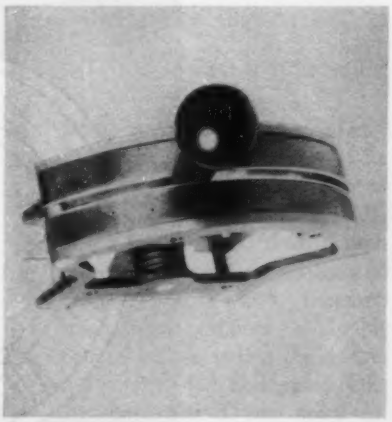
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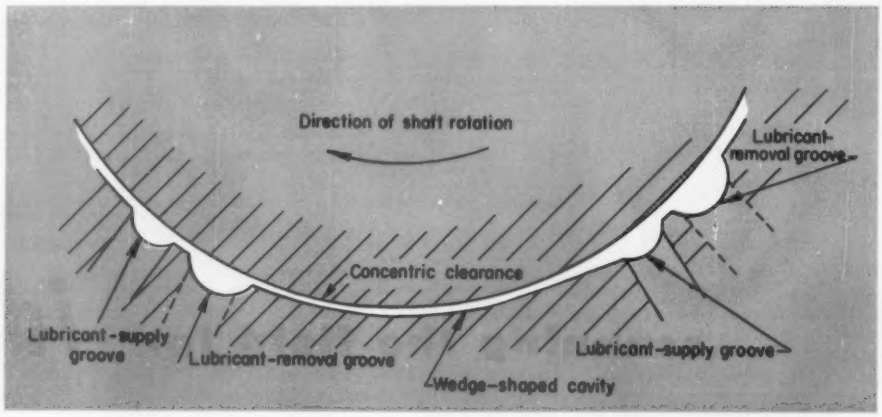
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2. W. Cavanagh and R. Gibson—"Phosphate Coating of Metal Surfaces for Industrial Use," *Plating*, June, 1955.
3. W. E. Pocock—"Chemical Conversion Coatings—Chromates," *Metal Finishing Guidebook*, 27th edition, 1959, Metal & Plastics Publications Inc., Westwood, N. J., p. 533.
4. M. B. Diggen—"Surface Treatments on Magnesium," *Metal Finishing Guidebook*, 27th edition, 1959, Metal & Plastics Publications Inc., Westwood, N. J., p. 510.
5. W. E. Pocock—"Finishes for Aluminum Alloys," *Metal Progress*, Oct. and Nov., 1956.

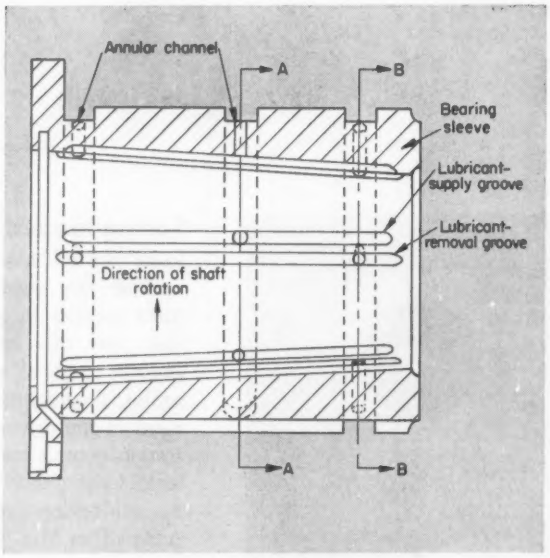
## scanning the field for *ideas*



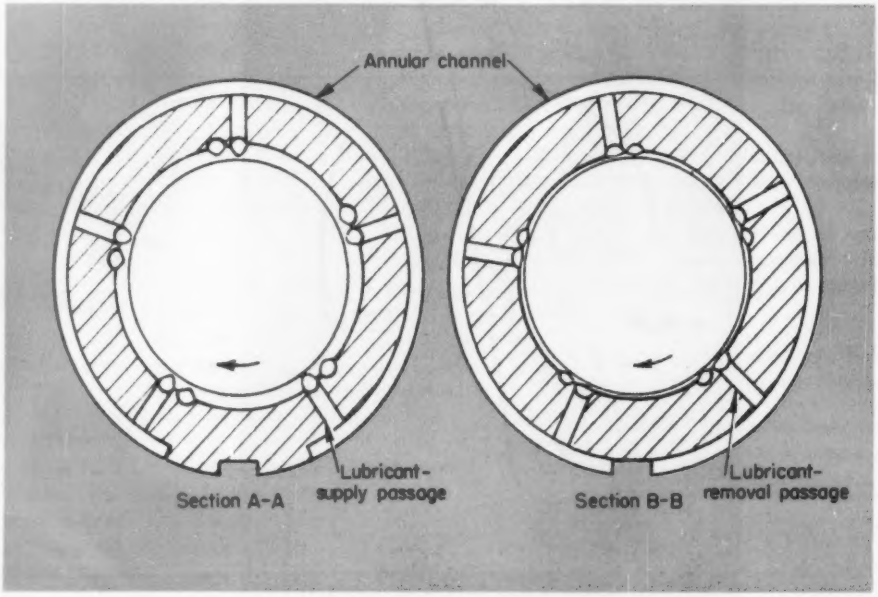

**Spring-loaded scissor** linkage locks control assembly against feedback at any quadrant position. Any force applied to the driven lever rotates the shoe assembly slightly, engaging one of two pairs of shoes against the quadrant. However, movement of the driving lever in either direction compresses the spring and releases locking shoe. Principle employed in self-locking control developed by Adams-Rite Mfg. Co., Glendale, Calif.

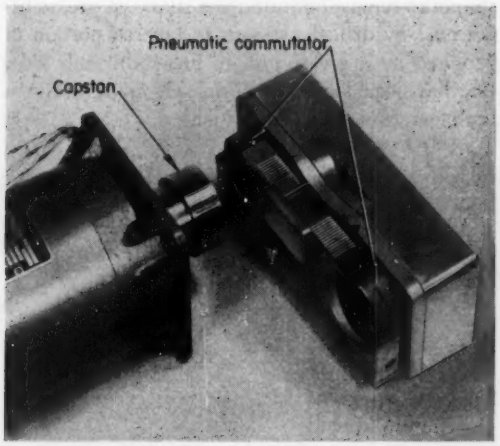




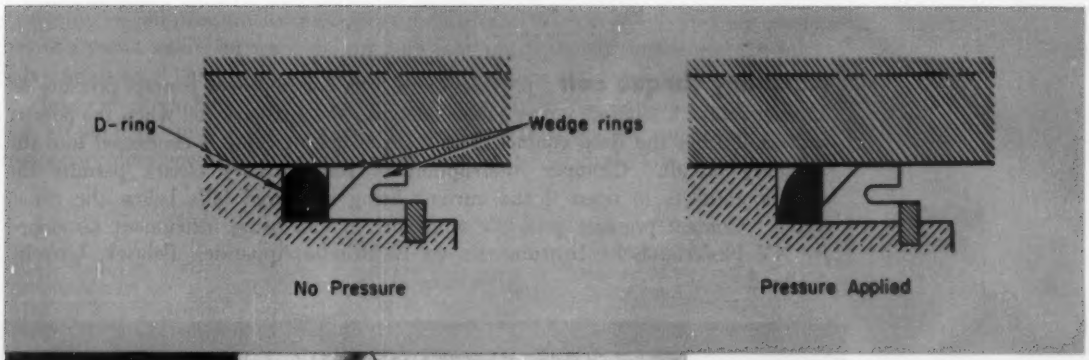



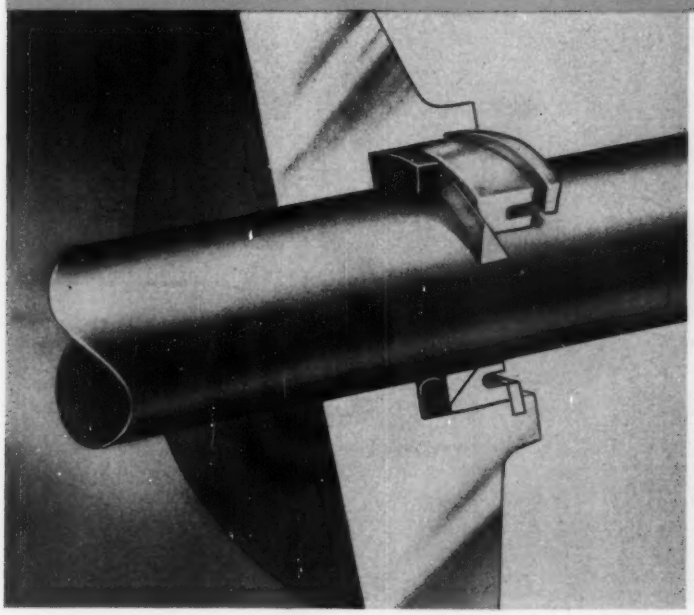

**Tapered hydrodynamic bearing** resists thrust as well as radial loads. A series of wedge-shaped cavities around the bearing bore are interconnected to a common lubricant supply. Corresponding removal grooves permit lubricant to return to cooler. Lubricating principle employed in grinding machine developed by Fritz Studer AG, Glockenthal/Thun, Switzerland.






**Vacuum capstans** provide gentle drive for tape of data-processing machines. Twin slotted drive cylinders rotate continuously in opposite directions. A carbon cylinder fits inside each cup-like capstan. A 90-deg segment of each carbon cylinder is connected to an electropneumatic control valve. To start tape motion, a vacuum is applied to the capstan rotating in the desired direction. Thus, the driving force is applied to a relatively large area of the tape. For reversal of tape direction, air pressure is applied to the first capstan and a vacuum applied to the opposite capstan. The system is capable of 200 start-stops per second continuously. Principle employed in data-processing system developed by Minneapolis-Honeywell Regulator Co., Minneapolis.

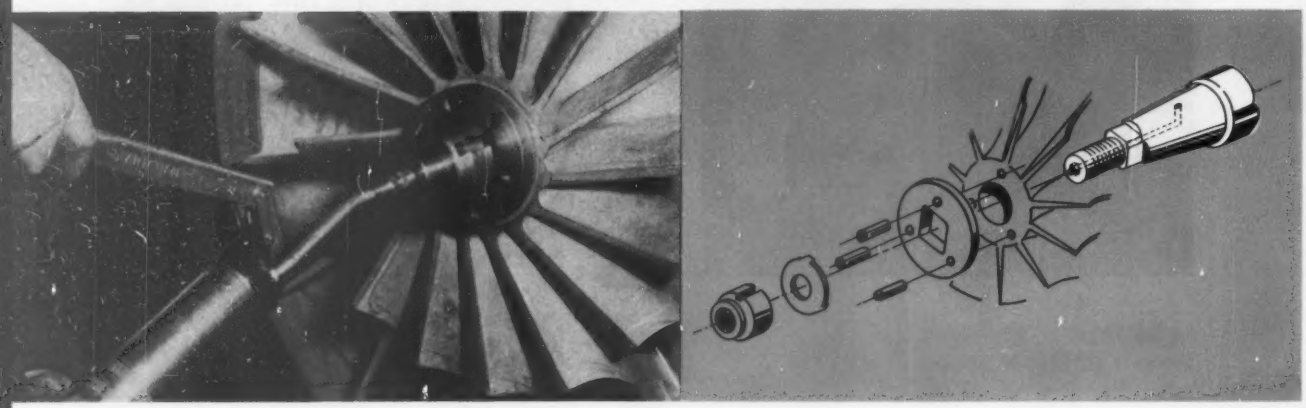


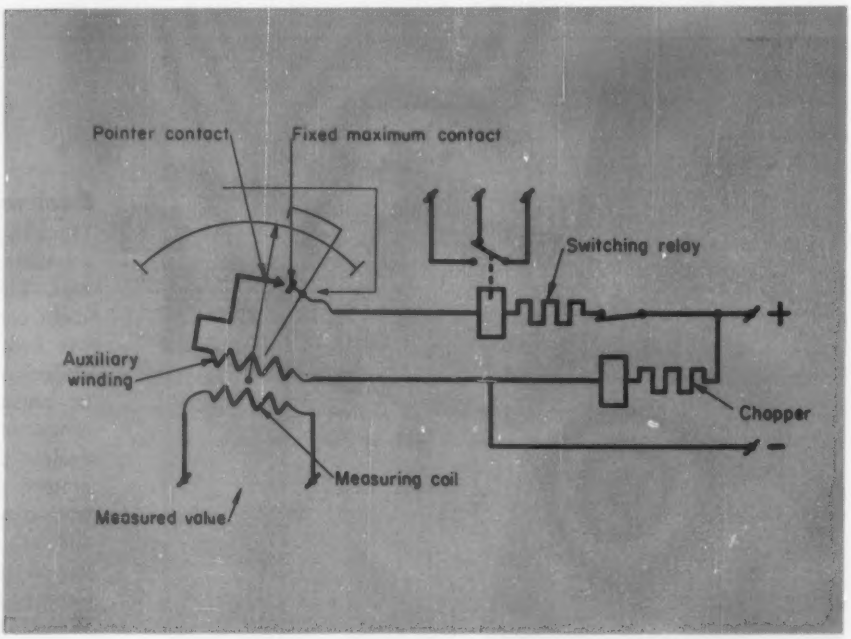
**Dual wedge rings** support a D-packing in a compact seal for installation in a simple counterbore. The D-ring, installed under slight compression, gives a positive seal. A lip on the second wedge serves as wiper. Increases in pressure produce a double cam action, extending the wedges against the rod and gland OD, protecting the D-ring from extrusion at the sealing interface and at its heel. Principle employed in seal developed by Greene, Tweed & Co., North Wales, Pa.

## SCANNING THE FIELD FOR IDEAS

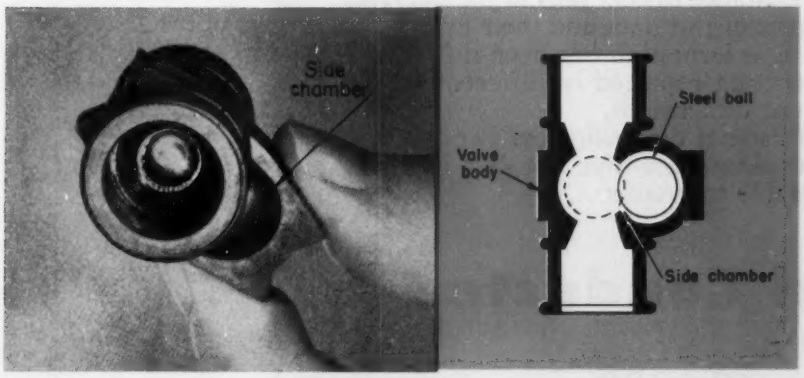
**Grease-gun break-away** simplifies removal of hub from shaft. A grease fitting in the end of the shaft is connected by drilled passages to tapered portion of the shaft. Hydraulic pressure is applied by a grease gun to break the hub loose from the shaft, after the drive plate has been loosened. Principle employed in a compressor developed by Allis-Chalmers Mfg. Co., Milwaukee.



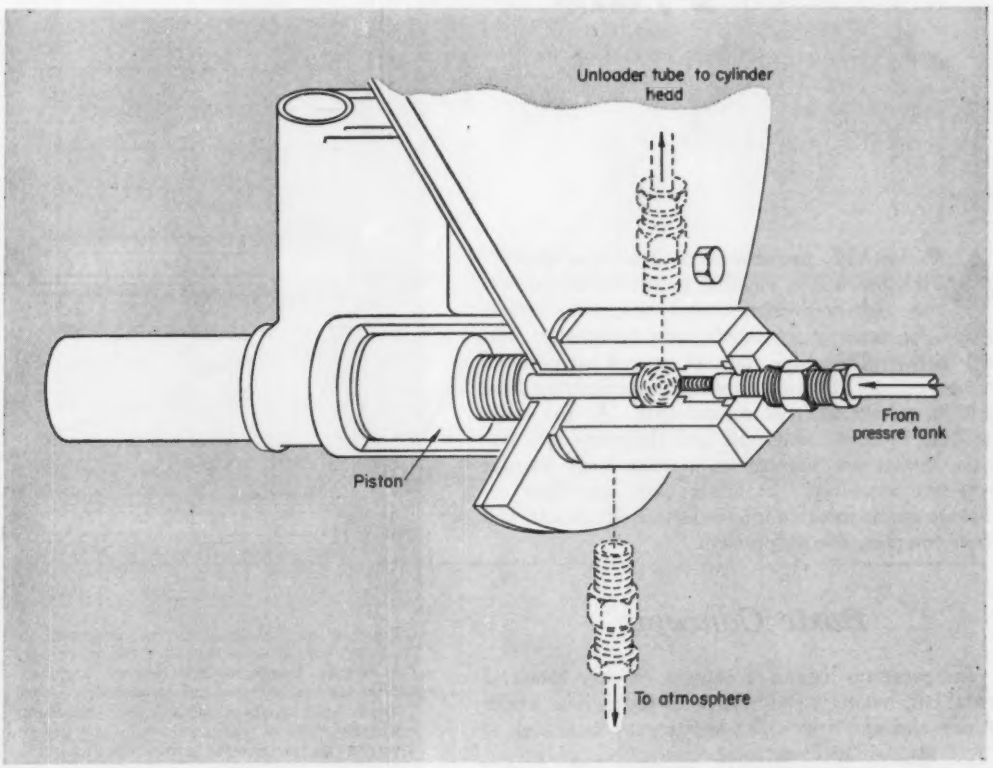
**Auxiliary torque coil** provides extra force for improved contact pressure on a meter relay. A separate power source energizes the auxiliary coil when the pointer contact touches the fixed contact. The main switching relay is connected into the auxiliary circuit. Chopper interruption of the auxiliary circuit permits the pointer contacts to open if the current being measured falls below the preset value. Contact pressure principle employed in measuring instrument developed by NV Nederlandsche Instrumenten-en Elektrische Apparaten Fabriek, Utrecht, Holland.



**Flexible valve body** permits pinch actuation of a low-pressure valve. A steel ball is housed in a side chamber to provide the open condition. To close the valve, the ball is squeezed from the side chamber into the closed position. Principle employed in valve developed by Arelco, Le Vallois-Perret, France.




**Loadless starting** plus low-oil-level protection for an air compressor are provided by an oil-pressure-actuated pilot unloader. Whenever oil pressure drops below a preset value, air from the pressure tank opens the check ball and the inlet valve unloader. During normal operation, oil pressure acts upon the pump piston to close the check ball. The trapped volume of air in the unloader is vented to the atmosphere, and normal operation is resumed. Principle employed in air compressor developed by Le Roi Div. of Westinghouse Air Brake Co., Sidney, Ohio.



**What happens to the flow of heat across a metallic joint when pressure at the joint is increased?**
**Does a smooth surface at the interface increase heat flow, as compared to a rough interface surface?**
**How does the metal hardness affect conductance?**
**These questions have been extensively analyzed and researched—complex analytical expressions have been developed to predict resistance to heat flow at the interface. Despite the abundance of test data and their evaluation, utilization of existing information has been difficult because the data have been reported in different ways—usually with different dimensions.**
**This article incorporates a dimensionless parameter in the analysis and correlates extensive test data in a common form that is usable to predict . . .**

# Thermal Conductance *across* METAL JOINTS

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ACCURATE predictions of heat-flow characteristics across metallic joints are often vital in high-performance equipment. In missile design, for example, materials must be selected that will withstand the high thermal stresses encountered in operation. Design is aimed at minimizing heat flow to certain internal components. At the other extreme, in many electronic and thermoelectric systems, metals are selected to increase heat transfer from the assembly. In either case, heat-flow resistance across metallic interfaces is a significant, and often complex, design problem.

## *Basic Concepts*

Temperatures measured along a radially insulated metal bar, having a constant-temperature heat source at one end and a constant-temperature heat sink at

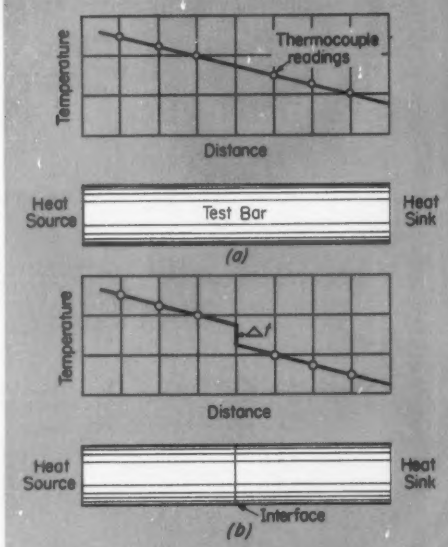
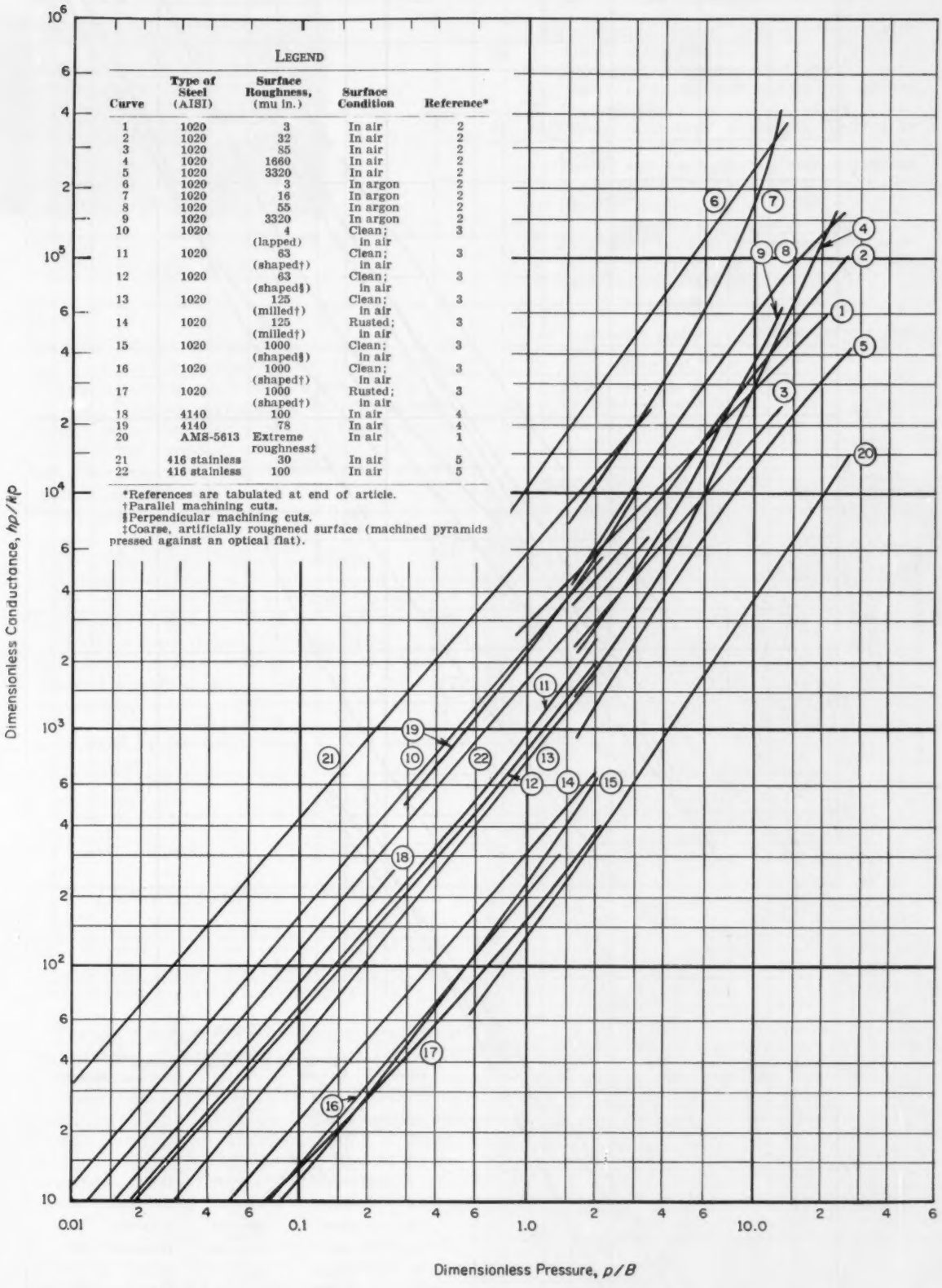



**Fig. 1—Comparison of thermal resistance in a solid bar, *a*, with that of a two-piece bar, *b*, whose interfaces are pressed together. Thermal resistance — or conductance — depends on interface smoothness, hardness, flatness, type of joint, pressure, and gas in vacant spaces between contact points.**

*Also Chairman of the Mechanical Engineering Dept., Southern Methodist University, Dallas, Tex.

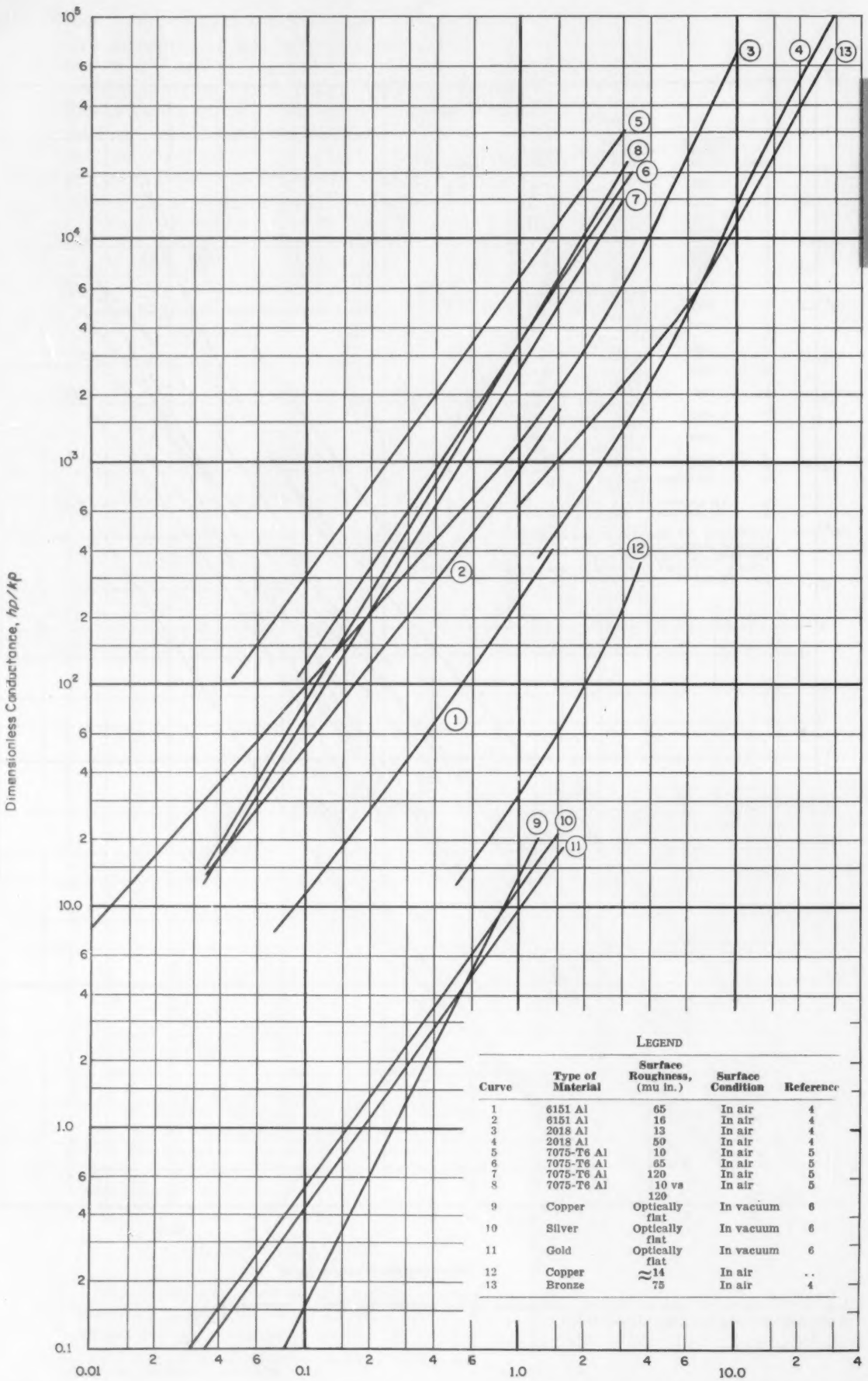



LEGEND

| Curve | Type of Steel (AISI) | Surface Roughness, (mu in.) | Surface Condition | Reference* |
|---|---|---|---|---|
| 1 | 1020 | 3 | In air | 2 |
| 2 | 1020 | 32 | In air | 2 |
| 3 | 1020 | 85 | In air | 2 |
| 4 | 1020 | 1660 | In air | 2 |
| 5 | 1020 | 3320 | In air | 2 |
| 6 | 1020 | 3 | In argon | 2 |
| 7 | 1020 | 16 | In argon | 2 |
| 8 | 1020 | 55 | In argon | 2 |
| 9 | 1020 | 3320 | In argon | 2 |
| 10 | 1020 | 4 (lapped) | Clean; in air | 3 |
| 11 | 1020 | 63 (shaped†) | Clean; in air | 3 |
| 12 | 1020 | 63 (shaped§) | Clean; in air | 3 |
| 13 | 1020 | 125 (milled†) | Clean; in air | 3 |
| 14 | 1020 | 125 (milled†) | Rusted; in air | 3 |
| 15 | 1020 | 1000 (shaped§) | Clean; in air | 3 |
| 16 | 1020 | 1000 (shaped†) | Clean; in air | 3 |
| 17 | 1020 | 1000 (shaped†) | Rusted; in air | 3 |
| 18 | 4140 | 100 | In air | 4 |
| 19 | 4140 | 78 | In air | 4 |
| 20 | AMS-5613 | Extreme roughness‡ | In air | 1 |
| 21 | 416 stainless | 30 | In air | 5 |
| 22 | 416 stainless | 100 | In air | 5 |

*References are tabulated at end of article.
†Parallel machining cuts.
§Perpendicular machining cuts.
‡Coarse, artificially roughened surface (machined pyramids pressed against an optical flat).

Fig. 2—Dimensionless plot of thermal conductance versus pressure for ferrous materials at mean interface temperatures of 70-200 F.




LEGEND

| Curve | Type of Material | Surface Roughness, (mu in.) | Surface Condition | Reference |
|---|---|---|---|---|
| 1 | 6151 Al | 65 | In air | 4 |
| 2 | 6151 Al | 16 | In air | 4 |
| 3 | 2018 Al | 13 | In air | 4 |
| 4 | 2018 Al | 50 | In air | 4 |
| 5 | 7075-T6 Al | 10 | In air | 5 |
| 6 | 7075-T6 Al | 65 | In air | 5 |
| 7 | 7075-T6 Al | 120 | In air | 5 |
| 8 | 7075-T6 Al | 10 vs 120 | In air | 5 |
| 9 | Copper | Optically flat | In vacuum | 6 |
| 10 | Silver | Optically flat | In vacuum | 6 |
| 11 | Gold | Optically flat | In vacuum | 6 |
| 12 | Copper | ≈14 | In air | .. |
| 13 | Bronze | 75 | In air | 4 |

Fig. 3—Dimensionless plot of thermal conductance versus pressure for nonferrous materials at mean interface temperatures of 70-200 F.

## Nomenclature

$A$ = Cross-sectional area of specimen perpendicular to direction of heat flow, sq ft
$B$ = Brinell hardness number
$h$ = Thermal conductance coefficient for joint interface, Btu/hr-sq ft-deg F
$k$ = Thermal conductivity of material, Btu/hr-sq ft-deg F/ft
$p$ = Pressure with which the two metal surfaces are pressed together, psi (psf in dimensionless $hp/k\rho$)
$q$ = Heat flux, Btu/hr
$T_m$ = $(t_1 + t_2)/2$, mean interface temperature, F
$t_1, t_2$ = Temperature found by extrapolation from source and sink ends respectively, toward a metallic joint and considered to be acting at the joint, F
$\Delta t$ = $t_1 - t_2$, temperature drop at interface, F
$\frac{dt}{dx}$ = Temperature gradient in direction of heat flow, deg F/ft
$\rho$ = Density of material, lb per cu ft
$\mu$ = Surface roughness, mu in.
$hp/k\rho$ = Dimensionless conductance
$p/B$ = Dimensionless pressure

the other, follow a uniform gradient, Fig. 1*a*. If the bar is cut, the faces finished to some specified degree, and the experiment reassembled, a new situation exists: The temperature gradient is the same as before in each of the bars, but at the interface, a discontinuity in the temperature-distance plot exists, Fig. 1*b*. The temperature drop is the result of thermal resistance of the joint.

The basic Fourier heat-conduction law is

$$q = -kA\left(\frac{dt}{dx}\right) \tag{1}$$

For two cylinders joined as in Fig. 1*b*, the same heat flux exists on each side of the interface. Thus, with a joint thermal-conductance coefficient, $h$, and the joint temperature drop, $\Delta t$, Equation 1 can be written for the joint as

$$q = hA(\Delta t) \tag{2}$$

from which, a relation between $\Delta t$ and $h$ can be developed as

$$\frac{\left(\frac{dt}{dx}\right)}{\Delta t} = \frac{h}{k} \tag{3}$$

## *Dimensionless Groups*

The work of many previous investigators of metallic-interface conductance can be correlated by two dimensionless groups—the approach used so effectively in most convective heat-transfer studies.

**Thermal Conductance:** The dimensionless group incorporating the thermal-conductance coefficient, $h$, is $hp/k\rho$.

Thermal conductance has long been known to increase as pressure forcing the surfaces together increases. Therefore, $h$ is multiplied by $p$ in the dimensionless group. The placement of $\rho k$ in the denominator, the latter suggested by Equation 3, completes the grouping.

**Pressure:** The second dimensionless group, $p/B$, relates the surface conditions of the materials at the interface and plays a significant role in heat transmission. Hardness, as used here, is defined as resistance of the material to surface penetration. Indention tests are easily accomplished; they are es-

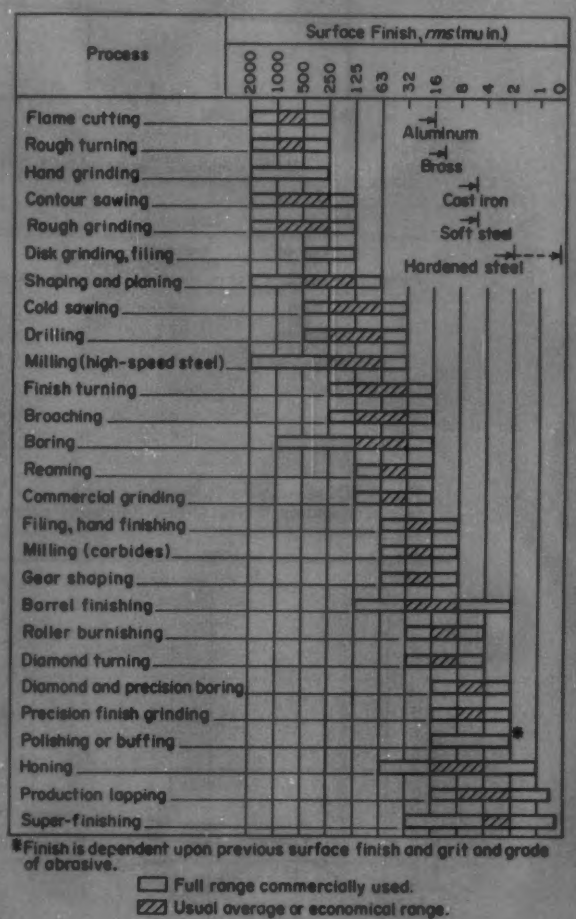
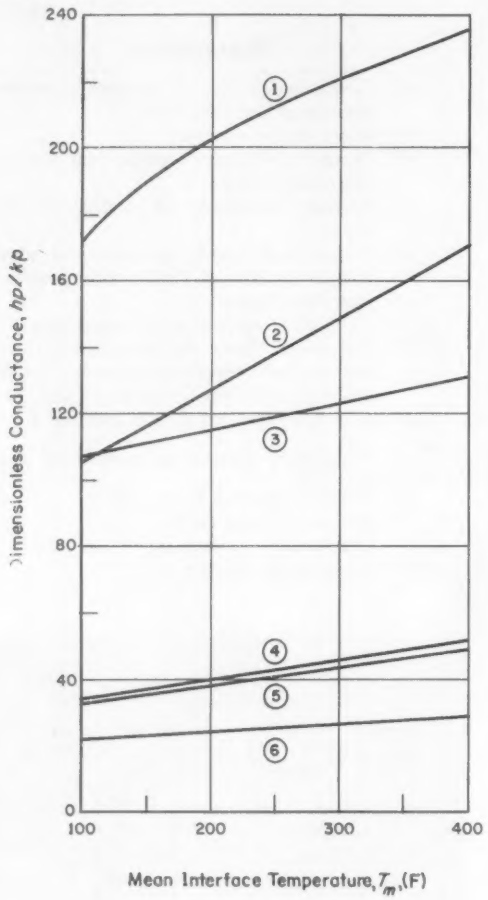


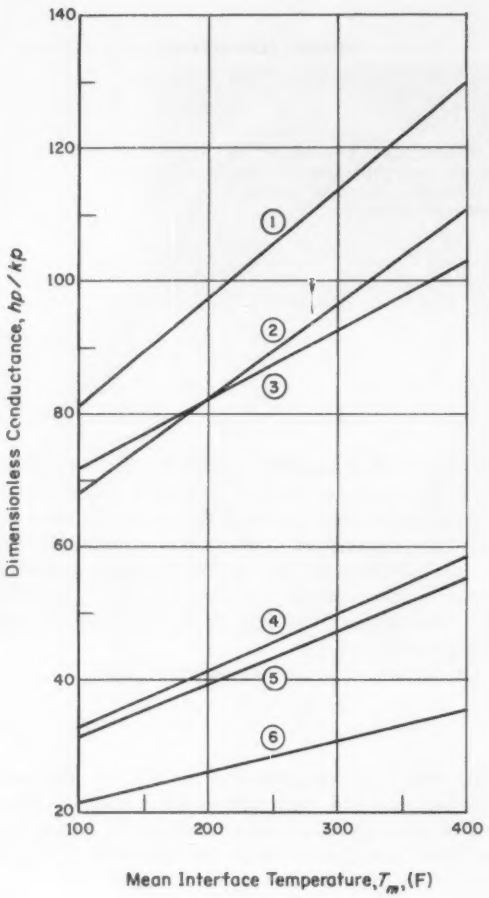

Fig. 4—Relation between basic finishing processes and ranges of surface roughness. Inset shows maximum practical surface fineness for five basic materials (these limits do not relate to processes listed opposite them in left column).




LEGEND

| Curve | Type of Steel (AISI) | Surface Roughness, (mu in.) | Pressure, p (psi) | Reference |
|---|---|---|---|---|
| 1 | 4140 | 10 | 10 | 4 |
| 2 | 416 stainless | 30 | 5 | 5 |
| 3 | 416 stainless | 40 | 7 | 7 |
| 4 | 416 stainless | 100 | 5 | 5 |
| 5 | 416 stainless | 110 | 7 | 7 |
| 6 | 4140 | 100 | 10 | 4 |

Fig. 5—Dimensionless conductance versus mean interface temperature (with surface-roughness parameter) for steel.




LEGEND

| Curve | Aluminum Alloy | Surface Roughness, (mu in.) | Pressure, p (psi) | Reference |
|---|---|---|---|---|
| 1 | 6151 | 16 | 10 | 4 |
| 2 | 7075-T6 | 10 | 5 | 5 |
| 3 | 7075-T6 | 13 | 7 | 7 |
| 4 | 7075-T6 | 65 | 5 | 5 |
| 5 | 7075-T6 | 65 | 7 | 7 |
| 6 | 6151 | 60 | 10 | 4 |

Fig. 6—Dimensionless conductance versus mean interface temperature (with surface-roughness parameter) for aluminum alloys.

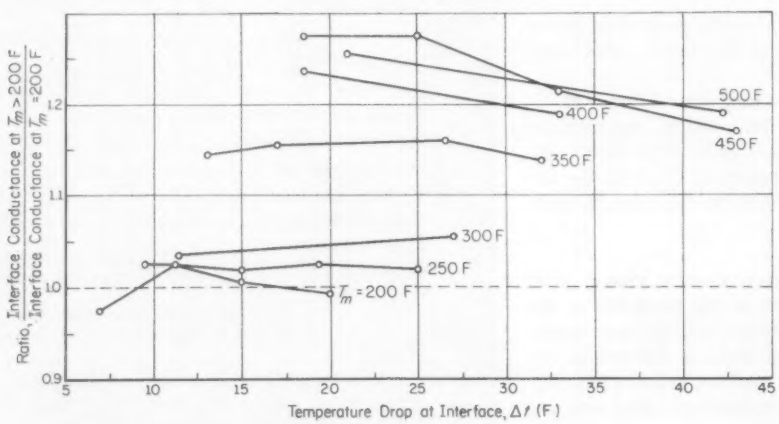



Fig. 7—Ratio of interface conductance versus interface temperature drop at various mean interface temperatures for stainless steel joints. Ratio for $T_m = 200$ F is "averaged out" (dash line) to equal 1.0. Data plotted is from Reference 7.

sentially nondestructive, and usually are considered nonmarring.

## *Dimensionless Plots*

Nondimensional plots of thermal conductance versus pressure for ferrous materials, Fig. 2, and for nonferrous materials, Fig. 3, are drawn for mean interface temperatures, $T_m$, of 70-200 F. Data reported at high values were corrected to 200 F. No data at temperatures below 70 F are represented in these plots.

The main reason that the curves of Fig. 2 and 3 do not lie together is the factor of surface roughness—a principal variable in the problem of heat flow. Surface roughness is defined as the summation of closely spaced surface irregularities, the height, width, and direction of which establish the pre-

### DESIGN EXAMPLE

**Problem:** Compare the steady-state-conduction heat flow through a plane wall made up of two sheets of the same material held tightly together by some mechanical means: 1. By the conventional composite-wall analysis. 2. By the composite-wall analysis taking into account the thermal conductance across the contact interface. Consider the sheets to be 7075-T6 aluminum, in air, each ⅛-in. thick and having surface roughnesses of 65 mu in. The faces are held together with a pressure, $p$, of 150 psi; $B$ is 150; $k$ is 70 Btu/hr-sq ft-deg F/ft; $\rho$ is 174 lb per cu ft. The outside surface of sheet $b$ is held at 300 F; the outside surface of sheet $d$, at 100 F.

**Solution 1:** The heat transferred through wall $b$, Fig. $A$, can be represented as $q_b/A$ Btu/hr-sq ft. Similarly, the heat transferred through wall $d$ is $q_d/A$ Btu/hr-sq ft. These values can also be shown as

$$\frac{q_b}{A} = \frac{k_b}{L_b}(t_1 - t_2)$$

and

$$\frac{q_d}{A} = \frac{k_d}{L_d}(t_2 - t_3)$$

Because of the steady state, $q_b/A = q_d/A = q/A$ and

$$\frac{q}{A} = \frac{1}{\frac{L_b}{k_b} + \frac{L_d}{k_d}}(t_1 - t_3)$$

$$= \frac{(1)(300 - 100)}{\left[\frac{0.125}{(12)(70)} + \frac{0.125}{(12)(70)}\right]}$$

$$\frac{q}{A} = 672{,}000 \text{ Btu/hr-sq ft}$$

**Solution 2:** The heat transferred through walls $b$ and $d$, Fig. $B$, is shown as

$$\frac{q_b}{A} = \frac{k_b}{L_b}(t_1 - t_2)$$

and

$$\frac{q_d}{A} = \frac{k_d}{L_d}(t'_2 - t_3)$$

and the heat transferred across the joint interface is represented by $q_{bd}/A$ or

$$\frac{q_{bd}}{A} = h(t_2 - t'_2)$$

As before, $q_b/A = q_{bd}/A = q_d/A$ and

$$\frac{q}{A} = \frac{1}{\left[\frac{L_b}{k_d} + \frac{1}{h} + \frac{L_d}{k_d}\right]}(t_1 - t_3)$$

Entering Fig. 3 (curve 6) with the value of $p/B = 1.0$, $hp/k\rho = 3250$. Solving, $h = 1830$ Btu/hr-sq ft-deg F (Note: The dimension of $p$ in $hp/k\rho$ is psf).

Solving for $q/A$

$$\frac{q}{A} = \frac{(1)(300 - 100)}{\left[\frac{0.125}{(12)(70)} + \frac{1}{1830} + \frac{0.125}{(12)(70)}\right]}$$

$$\frac{q}{A} = 237{,}000 \text{ Btu/hr-sq ft}$$

The large reduction in calculated heat flow through the composite wall when thermal contact resistance is included shows that metal interfaces, interposed in heat-flow paths of built-up structures, can cause sizeable increases in thermal stress of components. In some cases, however, the geometry of the joint may be more important than the conductance coefficient in determining over-all thermal resistance of the joint.[8]

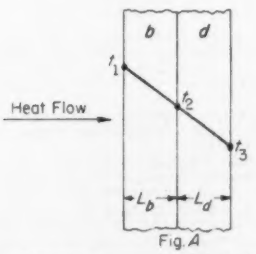


Fig. A

Theoretical contact between sheets $b$ and $d$

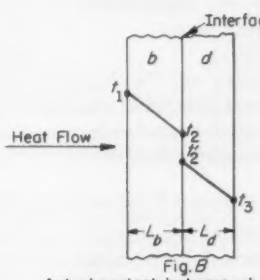


Fig. B

Actual contact between sheets $b$ and $d$

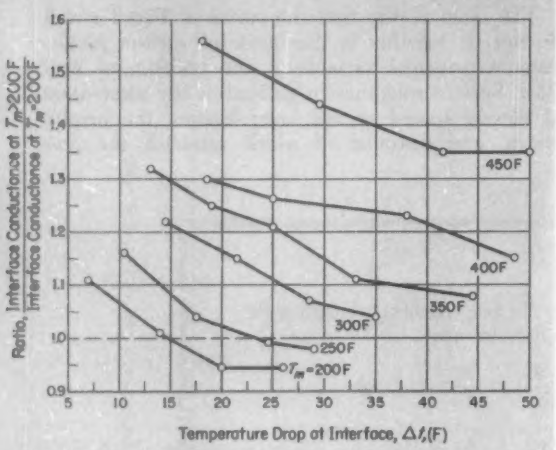



**Fig. 8—Ratio of interface conductance versus interface temperature drop at various mean interface temperatures for aluminum joints. Ratio for $T_m$ = 200 F is "averaged out" (dash line) to equal 1.0. Data plotted is from Reference 7.**

**Table 1—Tolerances and Surface Finishes**

| Tolerance (in.) | Surface Roughness (mu in.) |
|---|---|
| ±0.010 to ±0.005 | 250-64 |
| ±0.005 to ±0.002 | 64-32 |
| ±0.002 to ±0.0005 | 32-16 |
| ±0.0005 to ±0.0002 | 16-8 |
| ±0.0002 and less | Under 8 |

dominant surface pattern. Surface roughness measurement is in terms of height, in microinches, of the arithmetical average deviation from the mean surface (the perfect surface that would be formed if all peaks were cut off and used up in just filling the valleys below this surface).

Surface roughness measurements are also given as values of root-mean-square average deviation from the mean surface. Instruments calibrated to read rms values of surface roughness read 11 per cent higher on a given surface than those calibrated for arithmetical average. This difference was neglected in compiling data from the many investigators.

**Surface Roughness:** Basic machining and finishing operations are related to their general ranges of surface roughness in Fig. 4. A guide to the relationship between working tolerances and surface finishes is shown in Table 1.

**Temperature Variation:** The extent of previous experimental work on contact thermal conductance makes possible the plotting of additional curves, useful in correlating temperature data. The relation between dimensionless conductance and mean interface temperature, $T_m$, at different surface roughnesses for ferrous and nonferrous materials, Fig. 5 and 6, is used to convert from one value of $T_m$ to another, regardless of pressure.

Thermal conductance is generally thought to vary with temperature drop, $\Delta t$, as well as with $T_m$, but some differences of opinion exist among investigators as to the direction of variation. Relationships among these variables for stainless steel and for aluminum joints, Fig. 7 and 8, indicate a tendency for thermal conductance to decrease slightly with increase in $\Delta t$ when mean interface temperature and pressure are held constant. The opposite trend is upheld by some investigators[5] who feel that the tendency for conductance to increase is the more likely in a statistical sense, considering the complete body of available data. Therefore, from a design standpoint, until more complete information is available, conductance is considered constant with changes in $\Delta t$ at constant pressure and mean interface temperature. This amounts to averaging out the slopes in Fig. 7 and 8 when these curves are used to make design predictions from one value of $T_m$ to another.

For any mean interface temperature from 70 to 200 F (as in the *Design Example*), Fig. 3 is used directly. When $T_m$ is greater than 200 F, the following procedure is recommended for estimating thermal conductance:

- Enter Fig. 2 or 3 with the correct $(p/B)$, estimate the proper surface-roughness location, and read the dimensionless conductance.
- Obtain a ratio, $R_1$, from Fig. 5 or 6 (accounting for surface finish approximately by interpolation) in the form:

$$R_1 = \frac{\left(\frac{h_1 p}{k\rho}\right) \text{ at desired } T_m}{\left(\frac{hp}{k\rho}\right) \text{ at 200 F}}$$

- Multiply the dimensionless conductance from Fig. 2 or 3 by $R_1$.
- With proper pressure, thermal conductivity, and density, solve for $h_1$.
- Enter Fig. 7 or 8 at the correct $\Delta t$ and averaged mean interface temperature to get the ratio, $R_2$:

$$R_2 = \frac{\text{Interface thermal conductance at desired } T_m}{\text{Interface thermal conductance at } T_m = 200 \text{ F}}$$

- Solve $(hp/k\rho)$ from Fig. 2 or 3 for $h$ and multiply by $R_2$ to get the final $h$, say $h_2$.
- For conservative design, use the smaller of $h_1$ and $h_2$.


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*A new design analysis of*

# The Prestressed Bolt

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When does a force produce additional stress in a prestressed bolt?
Does a resilient gasket at the joint change the answer?
Even design handbooks are somewhat at odds on this controversial subject.
This new analysis of an old design problem presents the argument that the added force *always* causes an increase in bolt stress.

ACCORDING to Hooke's law, deflection is proportional to applied force. When a prestressed bolt is subjected to an additional tensile load, the bolt elongates and is further stressed.

Some handbooks state that the bolt does not elongate until the value of the added load exceeds that of the prestress load. If this were true, it would be possible to build an infinitely rigid structure. The added load, regardless of magnitude, always increases the axial load of the bolt.

Most applications of a preloaded system involve a relatively rigid block or cylinder, compressed by relatively flexible bolts, Fig. 1*a*. Prestress load $P$ is induced by tightening the bolts.

Additional force $Q$ is then applied, Fig. 1*b*. Based on the hypothesis that the bolt elongates by additional amount $\Delta L$ due to force $Q$, the block also

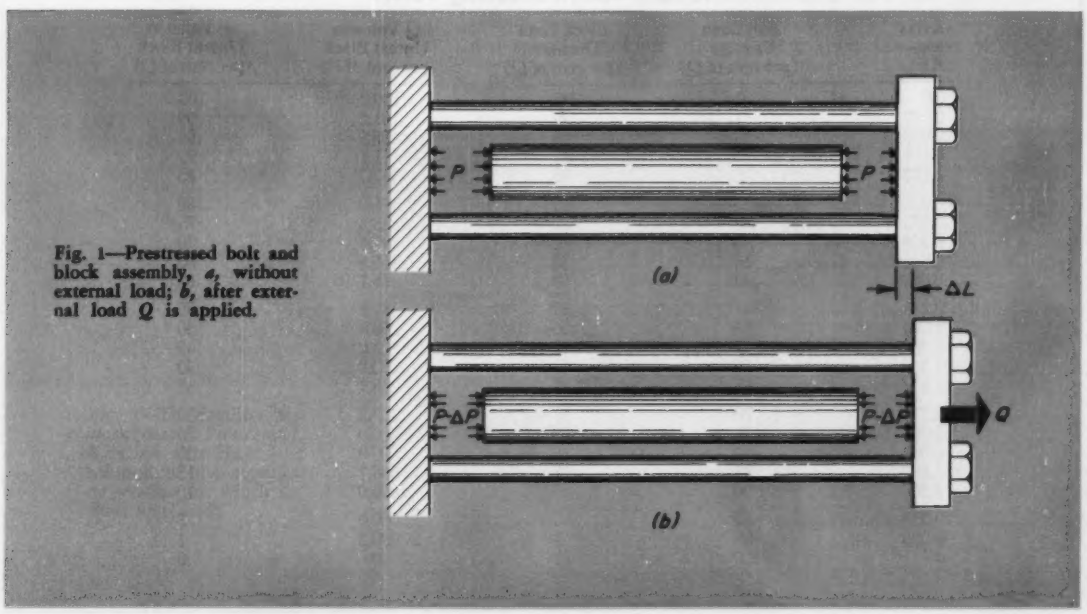



Fig. 1—Prestressed bolt and block assembly, *a*, without external load; *b*, after external load $Q$ is applied.

elongates the same amount. The force remaining in the block is $P - \Delta P$, where $\Delta P$ is some increment of load decrease. The bolt load, equal to block load plus $Q$, is then $P - \Delta P + Q$. Since both elements must deflect the same amount after $Q$ is applied, block deflection equals bolt deflection:

$$\frac{(\Delta P)L}{(AE)_c} = \frac{(Q - \Delta P)L}{(AE)_b}$$

This reduces to

$$\Delta P = \frac{Q}{\frac{(AE)_b}{(AE)_c} + 1}$$

Then the total bolt load, $F_b = P + Q - \Delta P$, or

$$F_b = P + Q\left[1 - \frac{1}{\frac{(AE)_b}{(AE)_c} + 1}\right] \quad (1)$$

and total block load, $F_c = P - \Delta P$, or

$$F_c = P - Q\left[\frac{1}{\frac{(AE)_b}{(AE)_c} + 1}\right] \quad (2)$$

From Equation 1 it is apparent that when product $AE$ of the block is large compared to that of the bolt, the bracketed term approaches zero and the bolt load increases by a small per cent of $Q$. Conversely, if the bolt is rigid relative to the block, the bracketed term approaches unity and the additional load on the bolt is almost equal to additional force $Q$.

The effect of preload is more obvious in Equation 2. The purpose of preloading is to prevent the compressed member from unseating, and to do this, $\Delta P$ must be less than $P$ by a comfortable amount. When $(AE)_c$ is large compared to $(AE)_b$, the bracketed term approaches unity, $\Delta P$ approaches $Q$, and preload $P$ must be larger than additional load $Q$. On the other hand, when $(AE)_b$ is significantly larger than $(AE)_c$, the bracketed term approaches zero and $P$ can be much less than $Q$, and still prevent unseating.

The most common design application usually requires determination of $P$ to be used with a known $Q$. Critical values (where unseating occurs) of $P$ and $Q$ are shown in Table 1.

Examination of Table 1 shows why, in some applications, a design could be based on the assumption that a bolt does not become additionally stressed until the added force exceeds prestress value—and still be nearly correct. In applications such as air compressors and hydraulic cylinders, the ratio of bolt rigidity to block rigidity is low—of the order of 0.05 to 0.1. Table 1 shows that in this rigidity range, critical preload $P$ is approximately equal to load $Q$, and that the axial load on the bolt increases by less than 10 per cent of $Q$. Thus, calculations based on an erroneous analysis can still provide adequate design in cases involving the low range of rigidity ratios.

### Nomenclature

$A$ = Cross-sectional area, sq in.
$E$ = Young's modulus
$F$ = Total load, lb
$\Delta L$ = Axial deflection, in.
$P$ = Preload force, lb
$Q$ = Added tensile load, lb

Subscripts:
$b$ = Bolt
$c$ = Block

**Table 1—Bolt Preloading Values**

| $(AE)_b$ / $(AE)_c$ | Bolt Load Increase (per cent of $Q$) | Block Load Decrease (per cent of $Q$) | $Q$ Value to Unseat Block (per cent of $P$) | $P$ Value to Unseat Block (per cent of $Q$) |
|---|---|---|---|---|
| 0.0 | 0 | 100 | 100.0 | 100 |
| 0.010 | 1 | 99 | 101.0 | 99 |
| 0.053 | 5 | 95 | 105.3 | 95 |
| 0.111 | 10 | 90 | 111.1 | 90 |
| 0.177 | 15 | 85 | 117.7 | 85 |
| 0.250 | 20 | 80 | 125.0 | 80 |
| 0.333 | 25 | 75 | 133.3 | 75 |
| 0.428 | 30 | 70 | 142.8 | 70 |
| 0.538 | 35 | 65 | 153.8 | 65 |
| 0.667 | 40 | 60 | 166.7 | 60 |
| 0.818 | 45 | 55 | 181.8 | 55 |
| 1.000 | 50 | 50 | 200.0 | 50 |
| 1.222 | 55 | 45 | 222.2 | 45 |
| 1.500 | 60 | 40 | 250.0 | 40 |
| 1.857 | 65 | 35 | 285.7 | 35 |
| 2.333 | 70 | 30 | 333.3 | 30 |
| 3.000 | 75 | 25 | 400.0 | 25 |
| 4.000 | 80 | 20 | 500.0 | 20 |
| 5.667 | 85 | 15 | 666.7 | 15 |
| 9.000 | 90 | 10 | 1000.0 | 10 |
| 19.000 | 95 | 5 | 2000.0 | 5 |
| 99.000 | 99 | 1 | 10,000.0 | 1 |
| ∞ | 100 | 0 | ∞ | 0 |

A curve family or a network chart is often the most direct form in which to plot the relationships of three variables. But, if such information is to be used recurrently in calculations, an alignment chart—or nomogram—is far more convenient.

This article shows how to design a simple template and how to use it to construct . . .

# Alignment Diagrams *from* Network Charts

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A NETWORK chart is a crude graphical computing device. One of its advantages is that it makes use of conventional Cartesian co-ordinates. In general, it works on the basis that Cartesian $U$ and $V$ co-ordinates fix a point on the chart through which some $W$ curve or line passes, Fig. 1.

Such a chart has disadvantages, also. For instance, if one wishes to read such a chart closely and not spend too long interpolating, then the need of

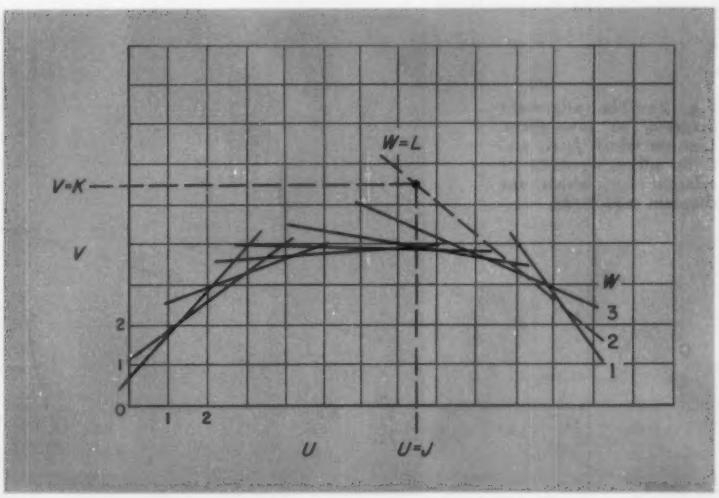



Fig. 1—The familiar network chart. Point at $J$, $K$, $L$ on this chart is a solution of the equation or relation for which the chart was made.

drawing a very fine network of $U$, $V$, and $W$ lines will make the surface of the chart very black and will obscure the very reading quality it was intended to aid.

## Alignment Diagrams

Now imagine a type of diagram where every line of the network chart is replaced by a point and every point by a line, Fig. 2. It is possible to make such a diagram yield the same results as the network chart. In it, a set of lines, like all the $U$ lines, will be replaced by a set of $U$ points arranged along a $U$ curve. A set of lines of $V$ values of the network chart will be replaced by a set of $V$ points along a $V$ curve. A set of $W$ lines will be replaced by a set of $W$ points along a $W$ curve. Some or all of these curves may be straight.

How will such a diagram be used? In the network chart, a solution was represented by a point through which there passed a $U$ line, a $V$ line, and a $W$ line. The corresponding $U$ point, $V$ point, and $W$ point of the new diagram will now lie on a line. If the $U$ and $V$ values are specified, the line can be drawn. Where it cuts the $W$ curve is the value of $W$ which satisfies the equation for which the chart was made. Such a chart is known popularly as an alignment diagram or nomogram, Fig. 2. It permits very fine reading because it is possible to put in points along the three curves as closely as wished down to the limits of observation without substantially affecting the readability of the entire diagram. The openness and ease of interpretation of such a diagram have been proved by experience.

## Converting a Network Chart to an Alignment Diagram

The question is how to take an equation which would ordinarily be put in the form of a network chart and express it in the form of an alignment diagram. A converter — a template — can be constructed for doing this job quickly and easily.

With this converter, any diagram or any functional relation that can be recorded in network chart form can also be quickly established in alignment diagram form. No knowledge of nomography is required, no concept of similar triangles, no familiarity with determinant forms or Euclidean geometry.

**Constructing the Converter:** Use a rectangular piece of transparent plastic, Fig. 3. A piece of tracing paper will do, but ultimately something more rigid like medium-weight clear plastic will be better. Say the plastic rectangle is 8 in. or so long and 6 in. or so high. Through its center $C$, draw two perpendicular lines parallel to the sides and call these the horizontal and vertical axes of the converter, Fig. 3. Mark off three linear $y$ scales on this rectangle, two of them congruent horizontal scales and one a vertical scale. The two horizontal ones are drawn equidistant from the horizontal axis, their zero points on the vertical axis and running in opposite directions. The third vertical $y$ scale need not be congruent to the other two.

Marks for these scales should be on the underside of the plastic, but the numerical values for them can be written on the upper side. This avoids any parallax of the marks.

Through center $C$ of the rectangle, drill carefully a tiny hole and run a black thread 6-in. long through it, knotting both ends so that it will not pull through.

The plastic rectangle is now prepared for use as a converter. It slides from side to side along the upper edge of a fixed horizontal straight edge.

**How To Use the Converter:** The network chart should be fastened down with a diagonal under the horizontal axis of the converter, Fig. 4. To find point $P_j$ of the alignment diagram corresponding to line $L_j$ of the network chart, slide the converter until the line passes through center $C$. Take the reading of the line on either horizontal $y$ scale and mark a point at the same $y$ value at the right-hand edge of

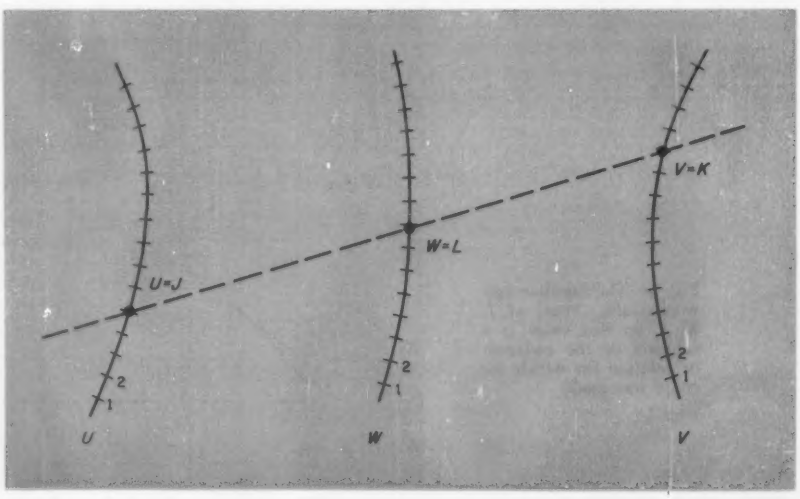



Fig. 2 — The alignment diagram, or nomogram. Line on which $J$, $K$, and $L$ lie solves equation or relation for which the diagram was made.

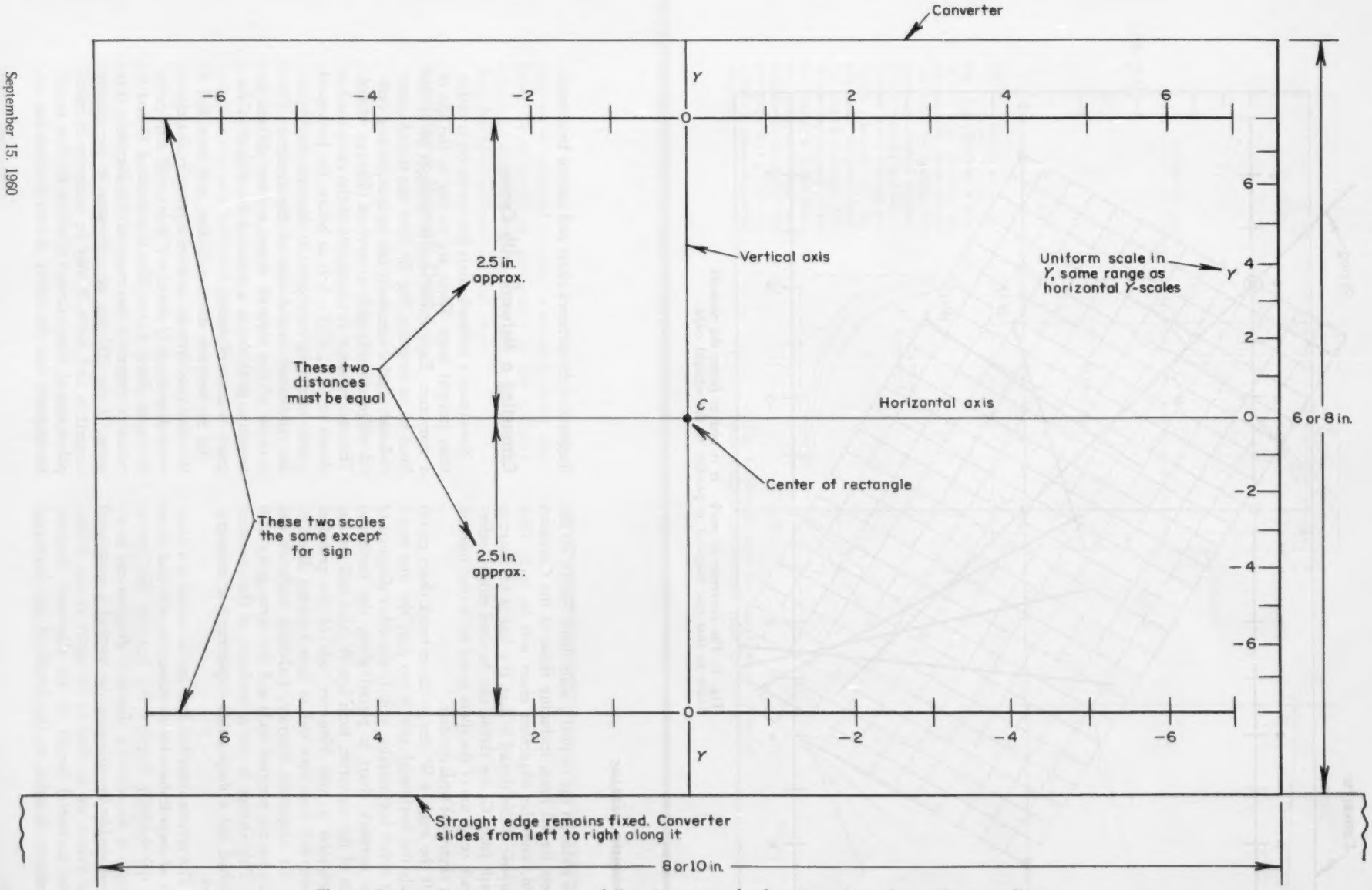



Fig. 3—Design of a simple converter of lines in a network chart to points of an alignment diagram.

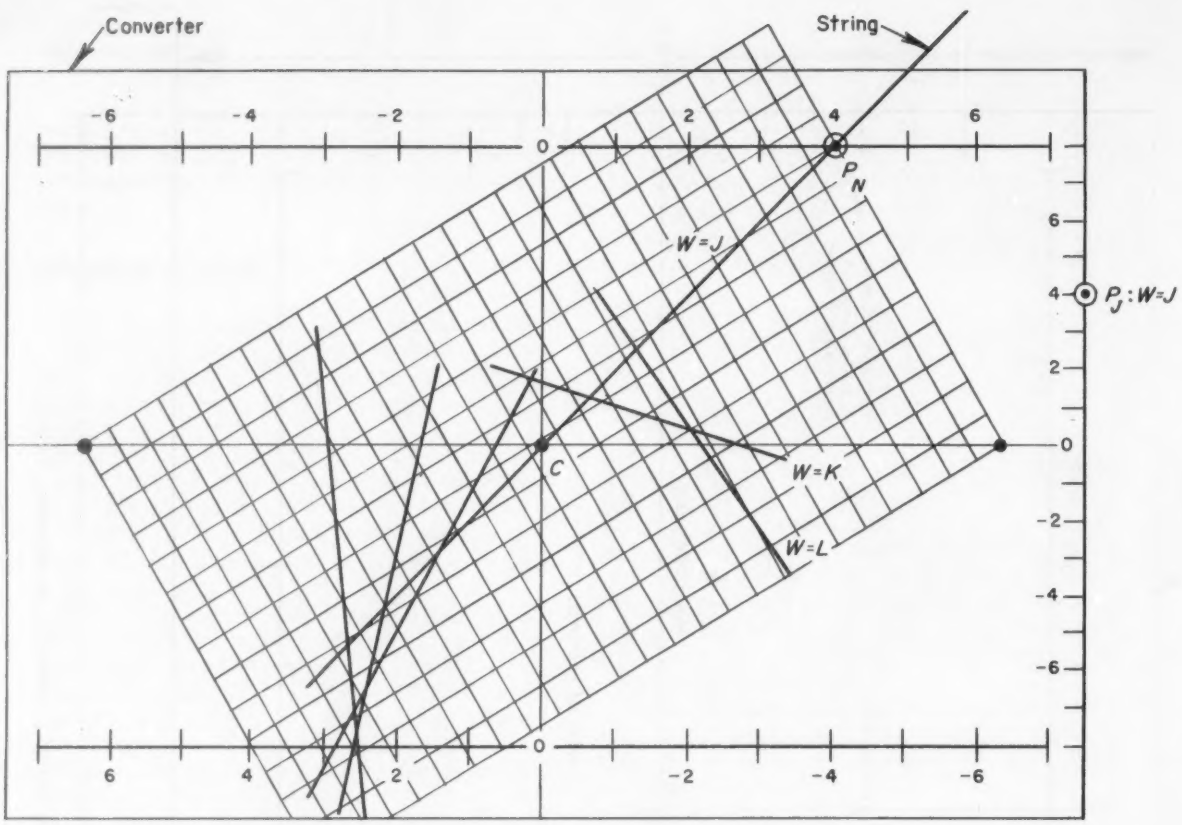



Fig. 4—The converter at work. It is best to fasten the network chart so that one diagonal is parallel to the straight edge.



the slider on the vertical $y$ scale there. Simply do the same for all lines, including those of the Cartesian grid, and the alignment chart will be built. One purpose of the thread is that, if a line is too short to reach point $C$, the thread can be used either underneath or on top of the slider to act as its continuation for alignment with the hole.

If the angle a $W$ line in the network chart makes with the horizontal axis is too low, the line won't cut either horizontal $y$ axis. If the other diagonal of the network chart is placed along the horizontal axis of the converter, such low $W$ lines will cut the horizontal $y$ axis. However, one of the principal scales will now turn out to have reversed direction in the alignment diagram. Italicized numerals can indicate the reversed scale and the curve going with it. This change is not a weakness of the converter method but a deep-seated requirement of nomography.

The process described here can be varied in a number of ways if desirable to change the size and shape of the resulting diagram. For instance, the vertical height of the resulting alignment diagram can be altered simply by changing the vertical $y$ scale until the values are as close or far apart as one wishes. The horizontal length of the alignment diagram, however, is equal to the length of the horizontal diagonal of the network chart and cannot be altered.

## Converting a Network with Curves

Sometimes a network chart has curves on it rather than straight lines. These are no bar to the use of a converter. Each curve can be thought of as defined by its tangents, Fig. 5*a*. Now the thread comes in handy again, because it can be brought to a careful tangency with such a curve as often as wished. This can be done at any points of the curve, and is shown in $C_AY_A$, $C_BY_B$. Just as before, the horizontal $y$-scale reading gives a point at the same reading on the right-hand vertical scale of the converter. Thus a curve of the network chart, a curve defined by tangents, gives rise to a curve of the alignment diagram—a curve of points.

In the network chart, a $U$ line, a $V$ line, and a $W$ curve pass through or share a point. In the alignment diagram, a $U$ point, a $V$ point, and a $W$ curve lie on, or share, a line. The line between $U$ and $V$ values is tangent to the curve in the alignment diagram. If the $UV$ line of colineation is not exactly tangent to any curve, it may be necessary to interpolate one of these curves (to which the line would be tangent) into the family of curves which has ac-

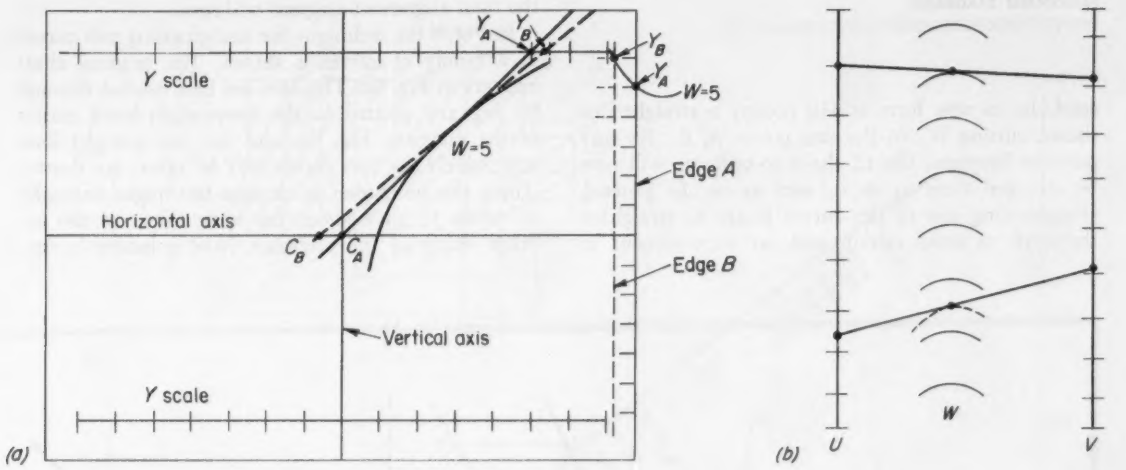



Fig. 5 — Dealing with curves. *(a)* A curve of the network chart can be converted by making the converter thread tangent to it repeatedly and drawing the curve through the points derived in the alignment diagram from the thread readings. *(b)* When the network chart has curves in it and these are converted into the alignment diagram, the resulting diagram is called a quasialignment diagram.

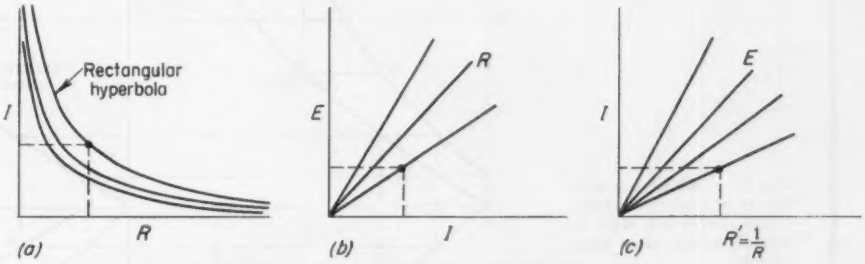



Fig. 6—Several ways for straightening curves algebraically in the network chart for $E=IR$.

tually been drawn, but this is not hard to do. The diagram so obtained is called a quasialignment diagram. It is almost as satisfactory as the ordinary alignment diagram, Fig. 5*b*. Its readability is greater than that of an ordinary network chart.

## Rectifying a Network Chart

For greatest convenience, a network chart should contain straight lines rather than curves. There are many ways to straighten, or rectify, network curves.

In Fig. 6*a*, function $E = IR$ has been plotted on $I$, $R$ axes. The family of curves here consists of rectangular hyperbolas and is difficult to plot. If the function is plotted on $E$, $I$ axes then $E/I$ is constant and gives rise to a family of straight lines in $R$, Fig. 6*b*. This suggests immediately another way of rectifying a family, namely, the substitution of $R' = 1/R$. Now $E = I/R'$ and when the function is plotted on $I$, $R'$ axes, a straight-line family, Fig. 6c, again is the result. Thus a change of family variable or a change of scale variable sometimes rectifies a family of curves.

In Fig. 7, the family behavior is again curved. One member only of this family, $W_k$, can be straight-

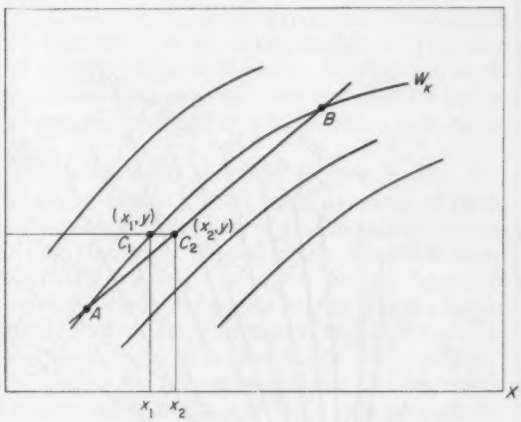



Fig. 7—The way to straighten one curve of the network chart before converting it into an alignment or quasialignment diagram. A new $x$ scale is developed by "moving" the curve into the straight line which is arbitrarily positioned.

ened. In its new form it will occupy a straight line shown cutting $W_k$ in the two points $A$, $B$. For any point in between, like $C$, the $x$ co-ordinate will now be changed from $x_1$ to $x_2$, and so on. In general, straightening one of the curves is apt to straighten them all to some extent, and an improvement in the final alignment diagram will result.

In Fig. 8 the technique for straightening two curves of a family of curves is shown. The original chart appears in Fig. 8*a*. The axes are first rotated through 90 deg and plotted in the lower right-hand corner of the diagram, Fig. 8*b*, and the two straight lines into which the two curves will be taken are drawn. These can be chosen at random but might naturally be taken to have about the same slopes as the average slopes of the originals. Now a ladder is con-

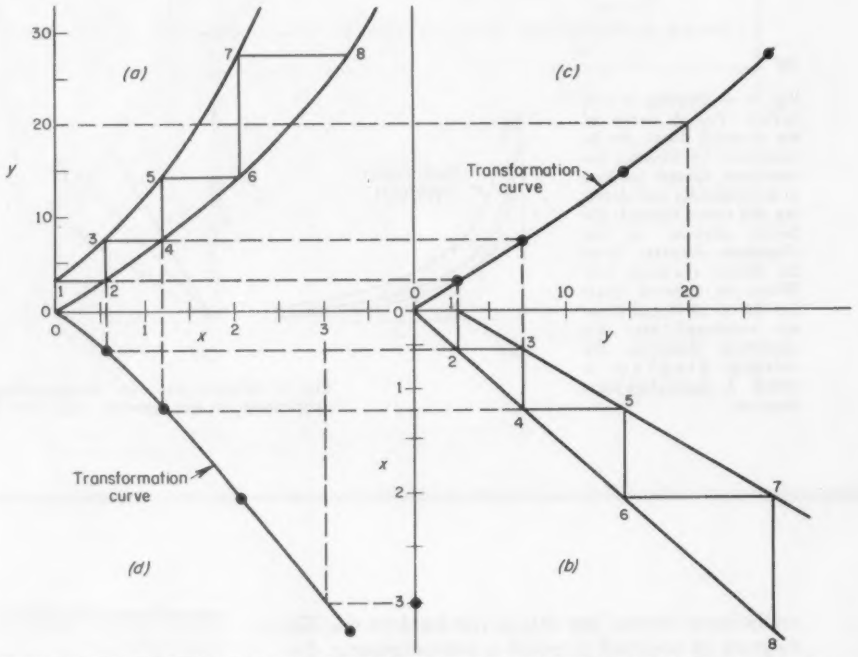



Fig. 8 — Rectifying two curves of a network chart. Other curves will tend to straighten out, often completely.

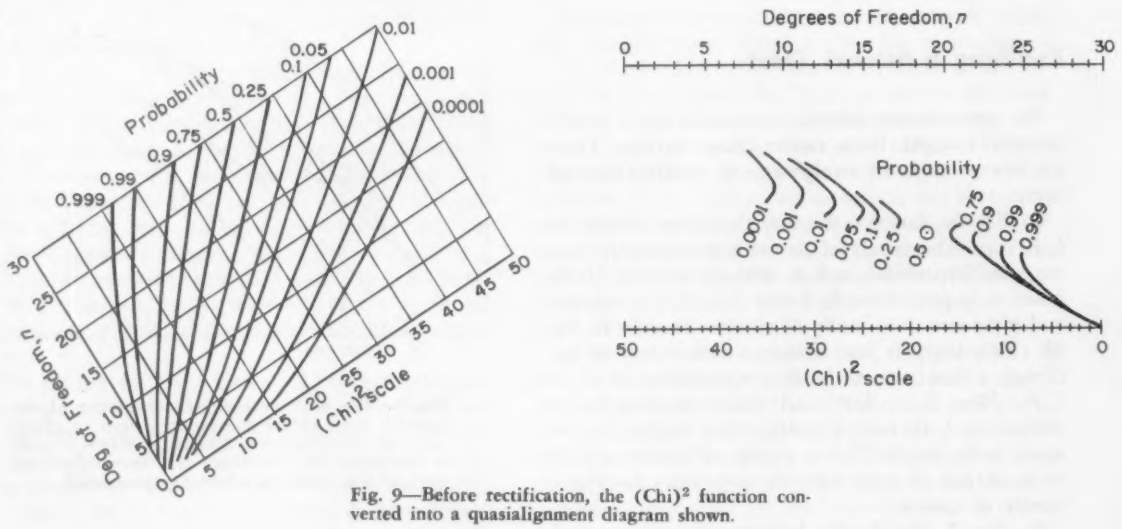



Fig. 9—Before rectification, the $(Chi)^2$ function converted into a quasialignment diagram shown.

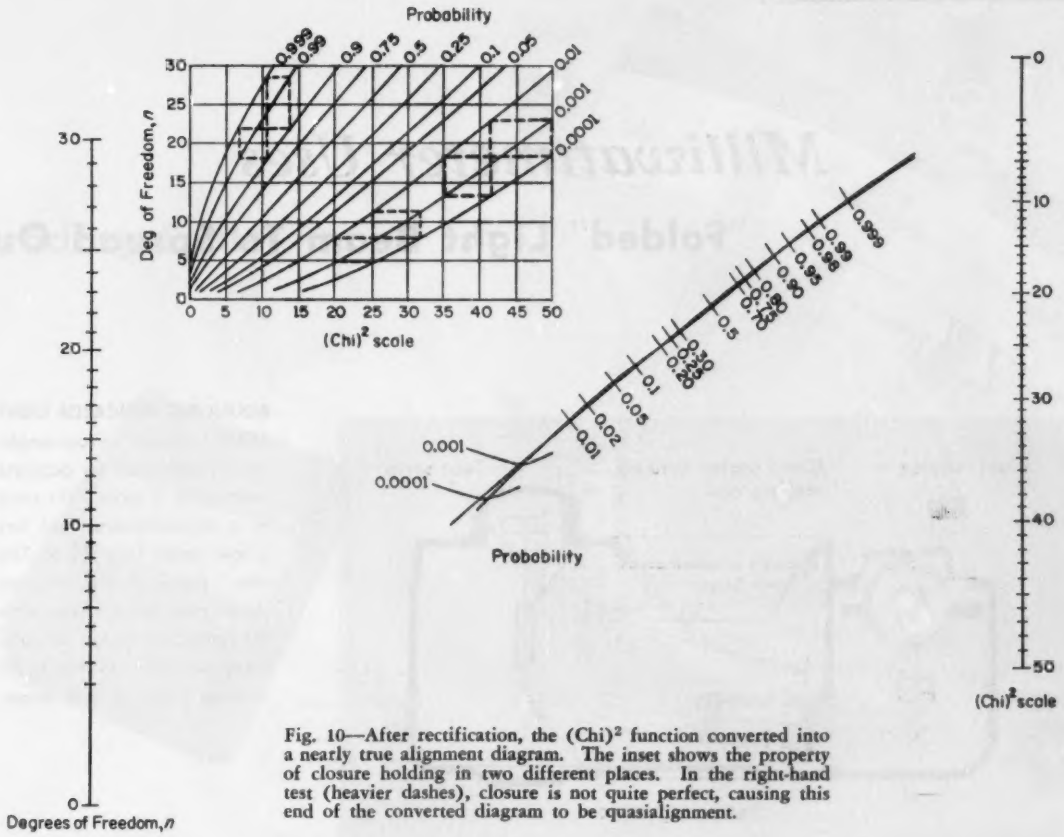



Fig. 10—After rectification, the $(Chi)^2$ function converted into a nearly true alignment diagram. The inset shows the property of closure holding in two different places. In the right-hand test (heavier dashes), closure is not quite perfect, causing this end of the converted diagram to be quasialignment.

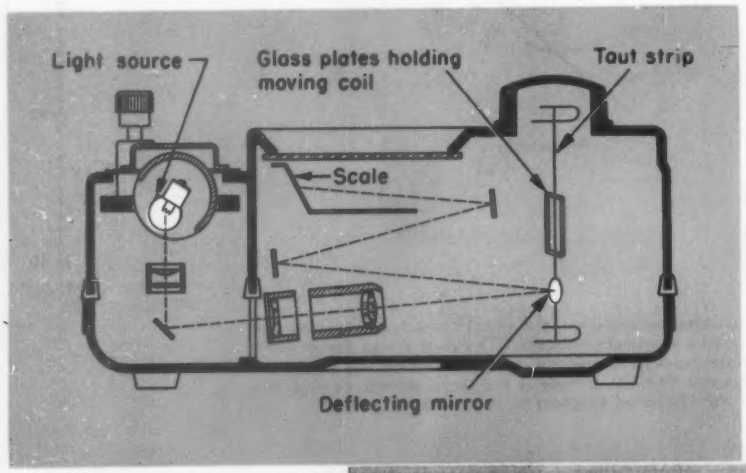
structed in Fig. 8*a* containing the original curves and a second in Fig. 8*b* containing the two straightened curves. Each ladder, or flight of steps, consists of lines joining two curves and parallel alternately to the two axial directions. The points are given corresponding numbers. From these numbers a transformation curve can be located in the upper right-hand corner, Fig. 8*c*, which will correlate equal values of $y$ from the left and from below. That is, line 3-4 for the left will meet line 3-4 from below to define the transformation curve at this point, etc. The same thing can now be done for values of $x$ in a transformation curve developed in Fig. 8*d*. When this process has been completed these transformation curves can be used to transform any other curves that may be a part of Fig. 8*a* into their counterparts in Fig. 8*b*.

Some rather remarkable results occur from this type of transformation. Although no one has succeeded in proving it, it has been known for a long time that a test is possible to determine whether or not all of the members of a family can be correspondingly rectified at one time. A rather unusual case of this is shown in Fig. 9—the famous $(Chi)^2$ function used in statistics. In Fig. 9, this network chart has been carried over, without benefit of rectification, into a corresponding alignment diagram by the converter process. Only one of the curves was naturally straight and the rather severe curvature of the others has given rise in the alignment diagram to some rather strongly curved quasialignment curves for the family of variables there. However, if two of the given curves are straightened, then practically all the others straighten. The chart then appears in the form of Fig. 10, where all of the curves have gone over into points except for two at the very end which have a reasonable gentle curvature.

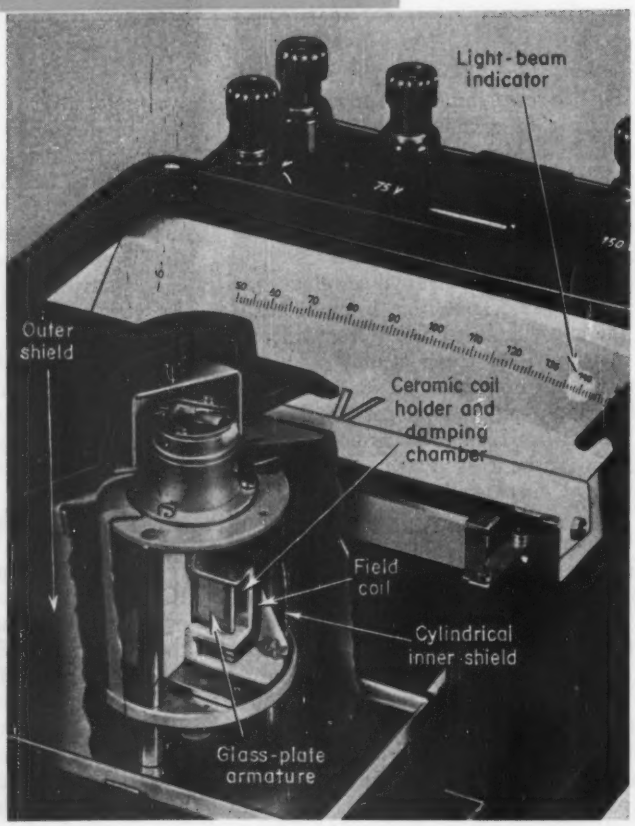
This result could have been foretold. In Fig. 10 is included a network chart with a closure diagram shown on it. This consists of a six-sided figure made of lines alternately parallel to the axes and based upon three successive members of the family of curves. When the figure starts from a point on the second of these three members, it comes back, or closes, perfectly on its starting curve. For this property of closure the following empirical theorem exists: If closure exists throughout the entire diagram for every six-sided figure of this form that can be drawn, then, when two of the curves are rectified, all the others will be rectified also. For the $(Chi)^2$ function, the closure property exists almost everywhere and almost all curves can be rectified. They are just a little weak in the lower right-hand corner of the diagram, giving rise to the two quasialignment curves at the values 0.01 and 0.001.

# *Milliwattmeter Uses*

## "Folded" Light Beam To Spread Out




**BOUNCING INDICATOR LIGHT BEAM** between mirrors amplifies its deflection for accurate reading on a scale. It's used in a milliwattmeter that has a low range from 75 to 750 mw. Although the diagram shows only two bounces after the deflecting mirror, actually there are four, so the small housing hides a 1-ft beam.

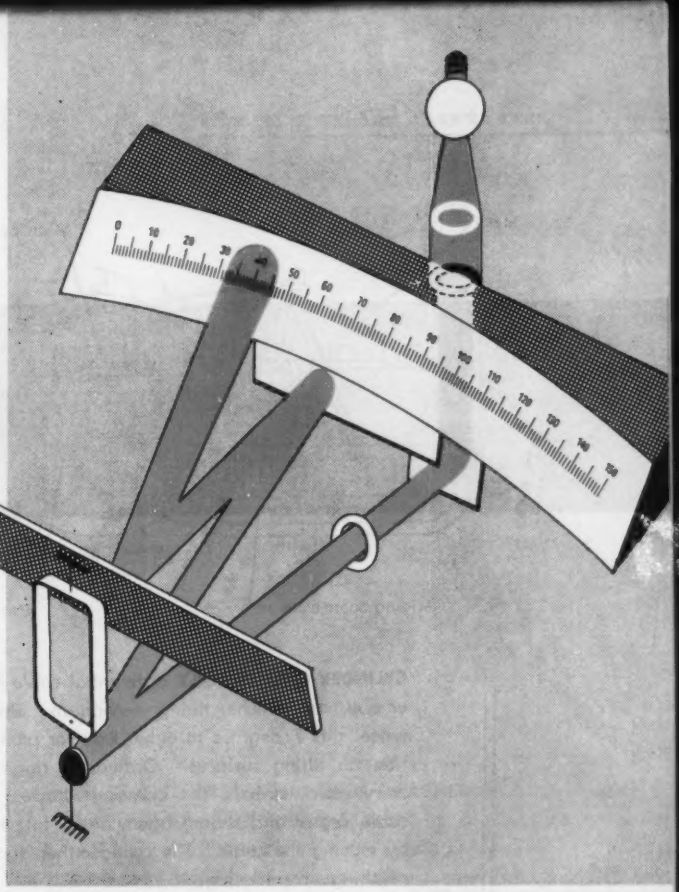



**DOUBLE SHIELDING** protects the coils from stray magnetic fields. Field and armature are each made of two symmetrically arranged coils for maximum fidelity in reading over the entire range. Mechanical damping is performed by glass plates swinging in the damping chamber formed by the ceramic field coil holders. A taut torsion strip (not shown in this view) supports armature and deflection mirror.

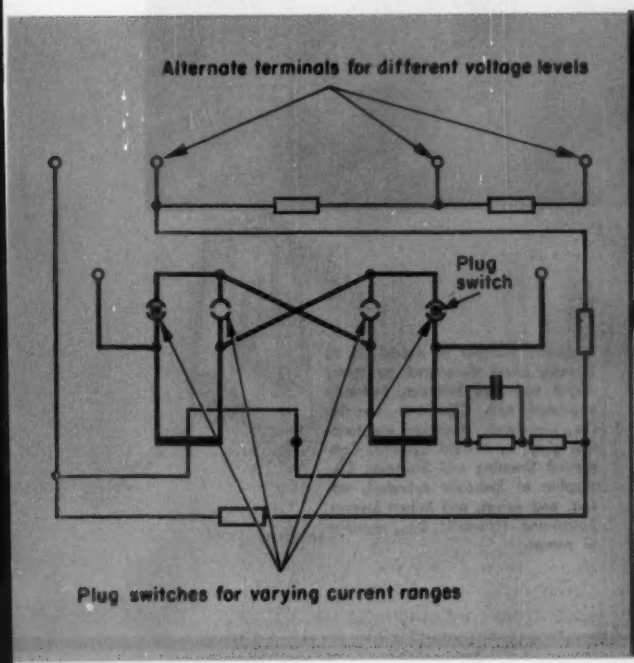
## Reading Scale



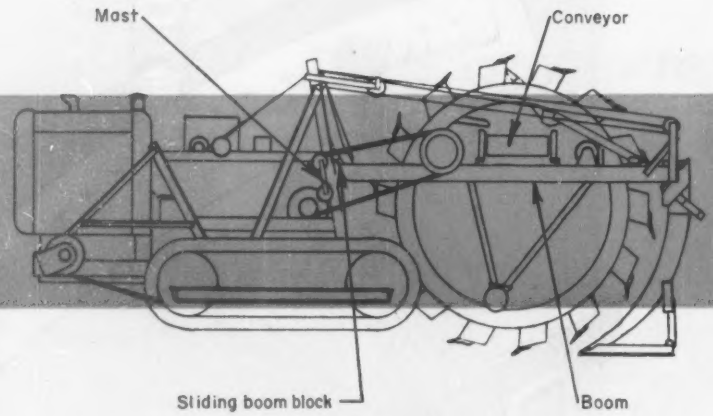
Miniature milliwattmeter is a design of Siemens & Halske AG, Karlsruhe, Germany.



**MEASURING RANGE IS CHANGED** by adjusting plug switches for four current ranges, or by using one of three terminals that matches input voltage most nearly. In all, the milliwattmeter will read at 12 different levels.

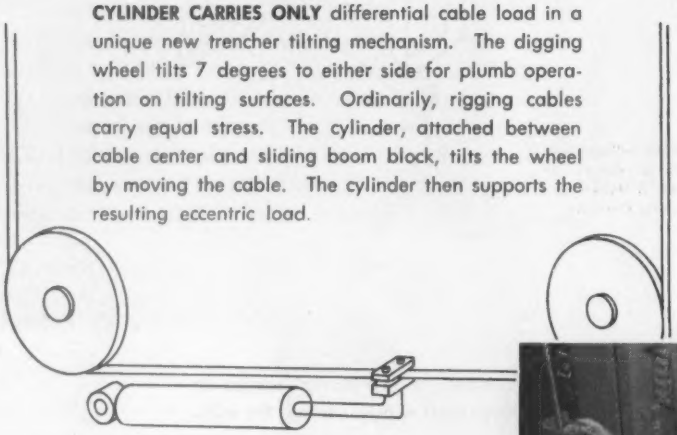


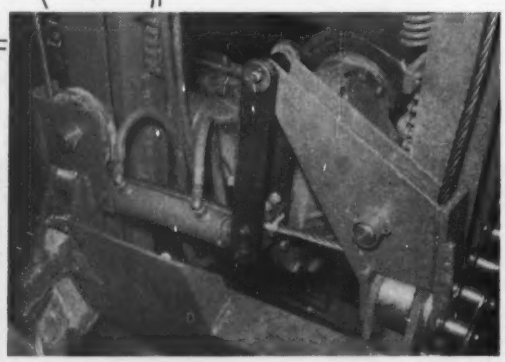



# Hydraulic Cylinders · Lift

**CYLINDER CARRIES ONLY** differential cable load in a unique new trencher tilting mechanism. The digging wheel tilts 7 degrees to either side for plumb operation on tilting surfaces. Ordinarily, rigging cables carry equal stress. The cylinder, attached between cable center and sliding boom block, tilts the wheel by moving the cable. The cylinder then supports the resulting eccentric load.



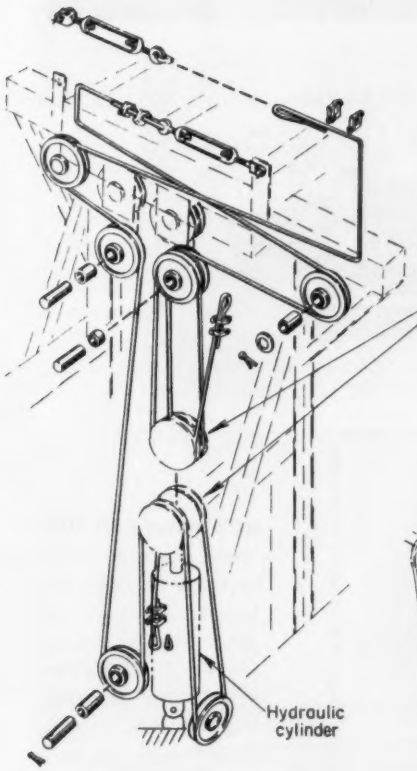




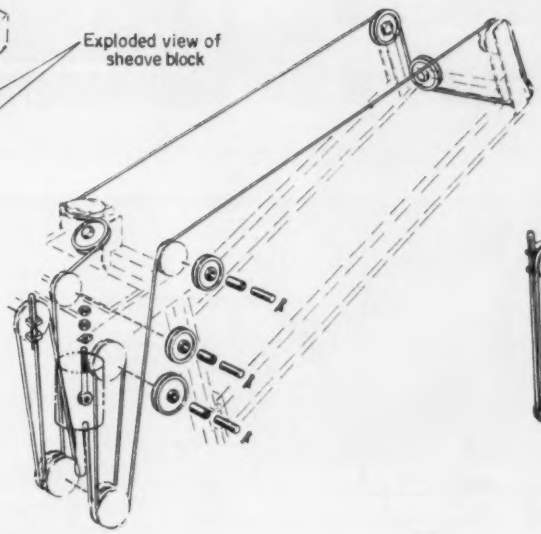
Hydraulic features of Model JS 30 Trencher were developed by Henry Meyer and Fred Wilhelm, hydraulic engineers with Cleveland Trencher Co., Cleveland. Technical assistance was given by Harold Cullings, Commercial Shearing and Stamping Co., supplier of hydraulic cylinders, motors, and valves, and Robert Stevens, Sundstrand Hydraulic Div., supplier of pumps.

# Control Rigging to Make Trench Digging Wheel
## • Lower • Traverse • Tilt

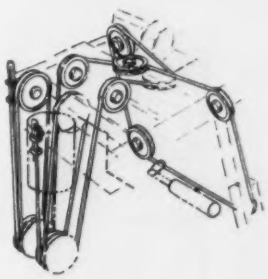
**UNUSUAL FLEXIBILITY HAS BEEN DESIGNED** into the trencher by putting mast and boom on a traverse bed for lateral positioning of the digging wheel. Necessary stability for heavy-duty operation is achieved by using hydraulic cylinders for traverse actuation along with a travel-multiplying cable-and-pulley system. Other motions using similar rigging include raising and lowering the boom outer end, and raising and lowering the boom inner end.




Mast Traverse



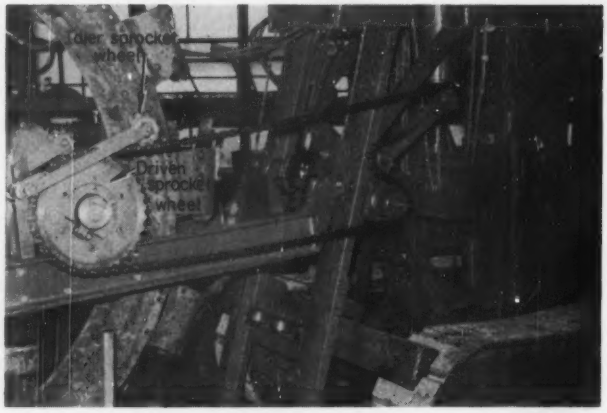

Rear Boom Hoist



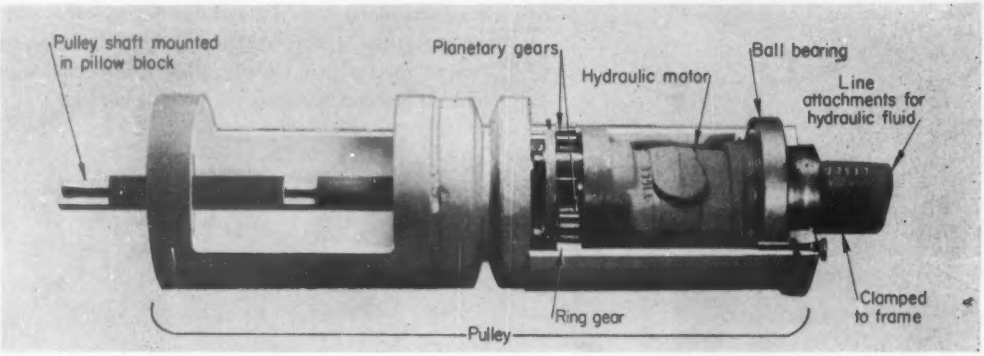
Front Boom Hoist

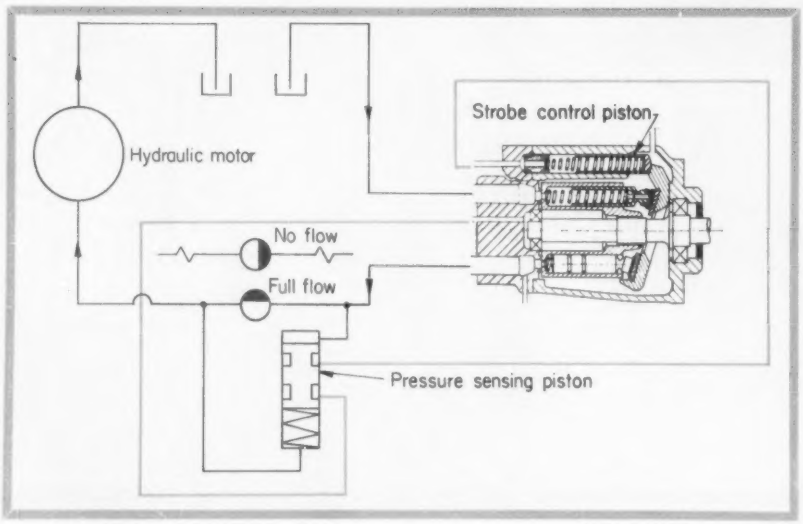
# Hydraulic Cylinders Control Rigging Of Trench Digging Wheel

**TILT CAPACITY EXCEEDS** the 4 degrees misalignment the digging-wheel drive chain and sprockets can accept. Idler sprocket wheel prealigns the chain for half of the tilt angle to bring total misalignment at any point within the required 4-degree maximum.



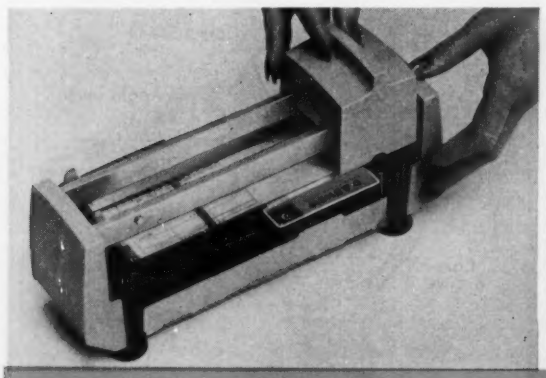

**CONVEYOR PULLEY ENCLOSES** hydraulic drive motor and planetary reduction gear. External connections consist of two bearing supports (one rigid), and hydraulic line connections. Dirt and dust are sealed out of oil-filled motor and gear chamber.

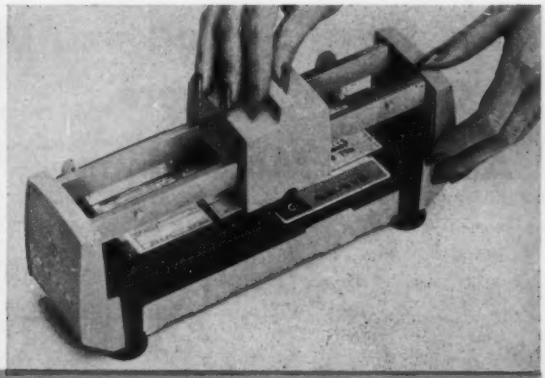



**FLOW VALVE CONTROLS** conveyor speed. Feedback from pressure differential across the valve changes pump stroke in response either to change in valve setting or change in work load. This keeps conveyor working at optimum speed for efficient clearing of dirt.

**PRINTING ROLLER IS SPRING LOADED** in a plastic housing to give necessary printing pressure. Pressure bar and levers or cams associated with most imprinters have been eliminated. A simple push and pull prints the form. Resulting print has the quality needed for automatic character reading. Ink or rubber rollers can be used with either embossed or inverse type.

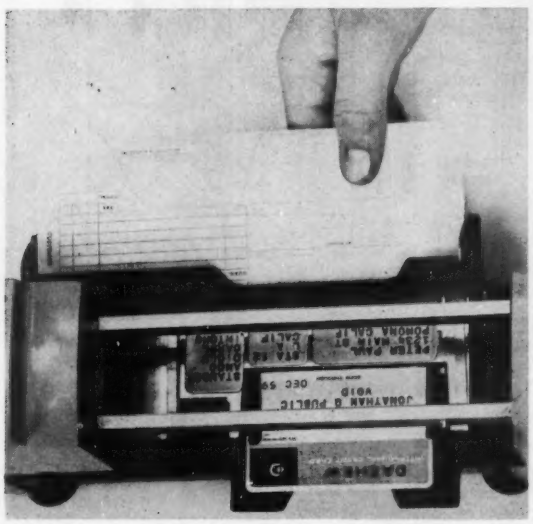


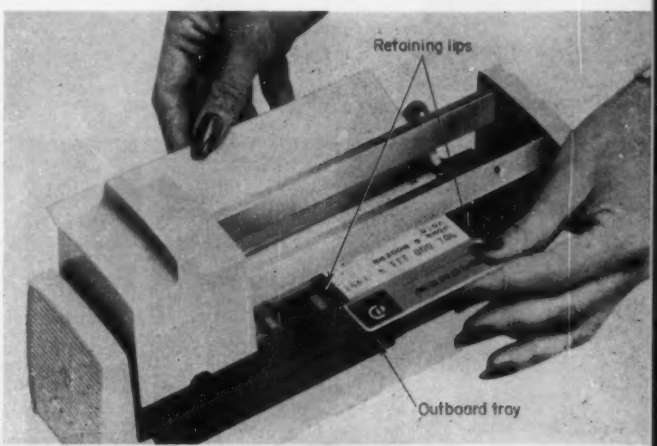


- Embossed
- Inverse
- Large
- Small
- Ink Roller
- Rubber Roller

## New Imprinter Handles All Credit Cards

**CARD SLOT ACCOMMODATES** both commonly used sizes of credit card. Widths are nearly the same—3⅜ vs 3½; either width will fit neatly under retaining lips. Outboard tray supports head of the taller card.

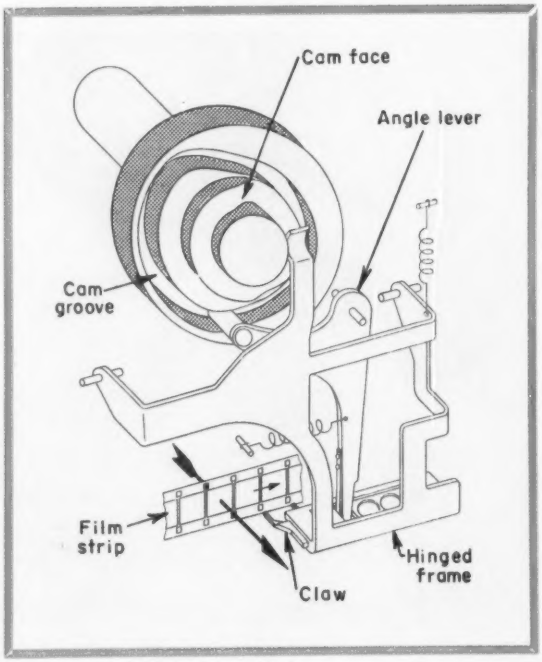




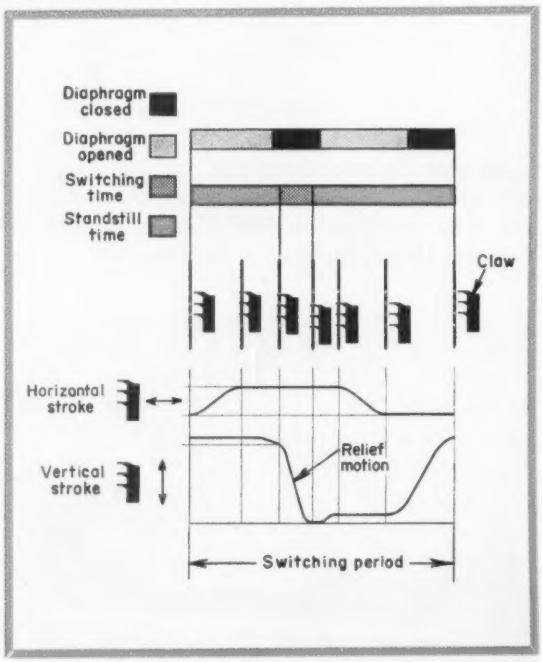

**FORMS ARE STORED** in a tray beneath the form chute where they are handy for quick one-motion insertion. Three permanent plates furnish flexibility in providing office information. For instance, in the example shown, there is a dealer plate, a station plate, and a multiple company plate showing the credit plan. Data-writer 19x3 is produced by Dashew Business Machines Inc., Los Angeles.

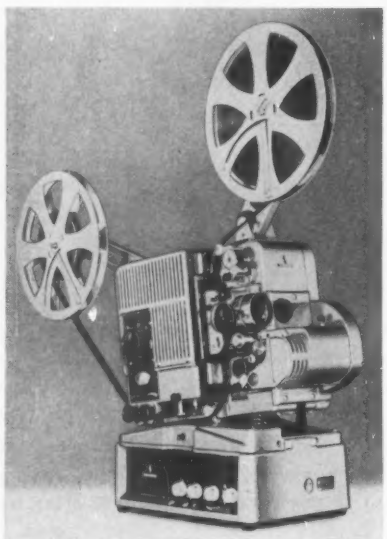
# Cammed Fingers Advance Movie Film

**CAM OPERATES** film-advance linkage in a movie camera. A forked claw is inserted into the film's sprocket holes to move it forward one frame at a time. Cam face operates a hinged frame to lift claw fingers clear of the sprocket holes. Cam groove controls an angle lever to synchronize forward movement with the engagement of the claw fingers.




**RELIEF MOTION** in the vertical stroke permits claw teeth to center on sprocket holes before retraction. This avoids wearing the film around the sprocket holes, and blurring the picture due to vibration as the claw fingers rub on the hole edges. Shutter diaphragm is open during retraction.

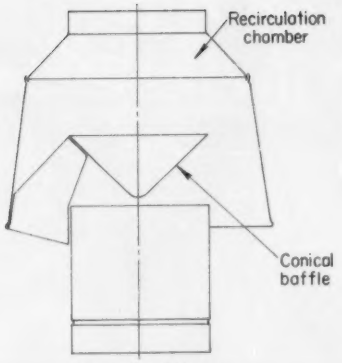


Movie projector employing the cam-operated film advance was developed by Siemens & Halske AG, Munich, Germany.

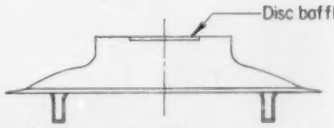
# Flat Disc Replaces Conical Deflector

# For Radically Low Burner Draft Hood

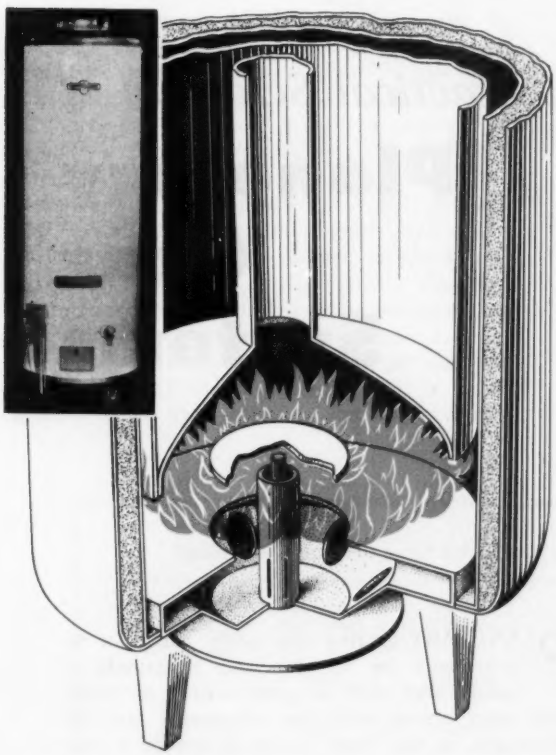


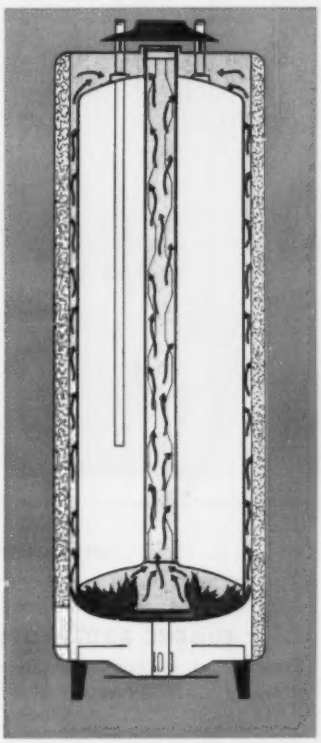
Conventional Hood

**GETTING AWAY FROM** conventional conical baffles, designers used a flat plate to baffle cold flue downdrafts in a new water heater. The resulting efficient straight-through flow of hot flue gasses makes possible a much shorter hood than the traditional design, which must allow for recirculation and mixing of hot flue gasses and downdraft. Actual height is 3 in. vs 14 in. for the conventional hood. Exterior of prototype hood was cool enough to touch.



New Hood





**DOUBLE AIR DELIVERY INSURES** even mixing of fuel and air in Bunsen-type burner. Primary air enters the burner through base slots in the conventional manner. Secondary air is guided by baffle plates to mix with fuel near outer flue passage to complete combustion in that zone. Additional air is also directed into the central flue passage. J-40 water heater developed by the Hotstream Heater Co., Cleveland, is said to have a recovery rate of more than a gallon per minute per 100 F rise.

**TURBULENCE IS AVOIDED** at the top of the tank by extending the inner flue through the upper chamber into the collar where gasses will be traveling in the same direction when they mix. Design problem was to maintain spacing between wall of tank and wall of jacket for annular outer flue passage. Solution was four leg-spacers which run the length of the jacket and hold the tank in the required position.

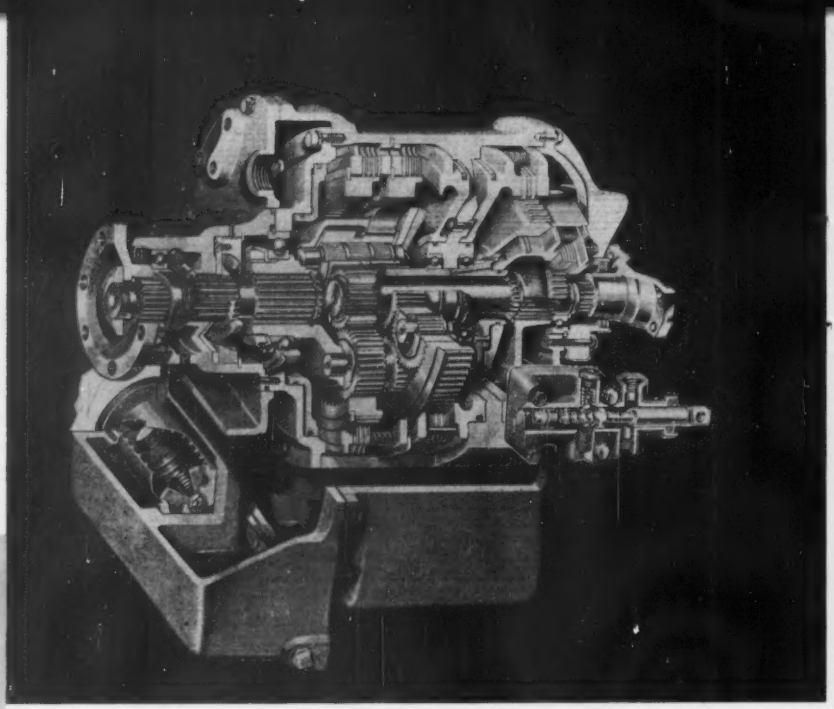
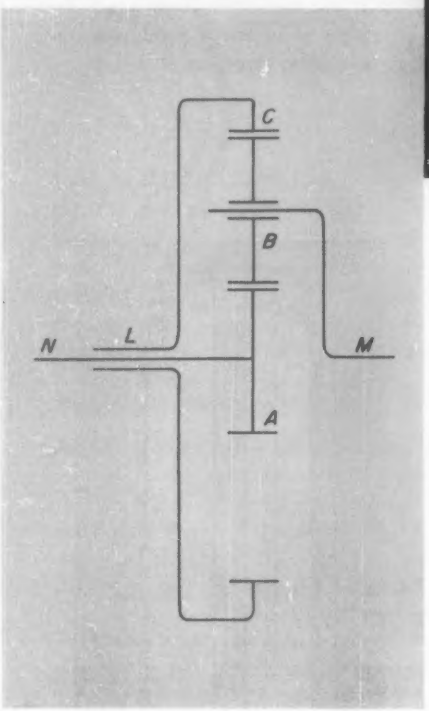


Fig. 1—Below—Arrangement of a simple planetary train with an internal ring gear. Each of three shafts may be used as a driving, driven, or fixed member.

*Photo at right courtesy Allison Div., General Motors Corp.*




# *Practical Selection of* Planetary Gear Systems

**EUGENE RADZIMOVSKY**
Professor of Mechanical Engineering
University of Illinois
Urbana, Ill.

PLANETARY gearing can satisfy particular requirements for number and magnitude of speed ratios with a great variety of trains. Each train arrangement has advantages and disadvantages, so the "best" design is usually a compromise between a number of factors. Some of the main factors are: Performance, reliability, simplicity, dimensions and weight, cost, and maintenance.

Because of the large number of factors and combinations of factors, initial selection of the most suitable planetary gearset is difficult. One way is by trial-and-error—developing a large number of possible schemes, investigating each, then selecting the apparent best. Trial-and-error, however, has two basic weaknesses: First, the number of possible combinations for one transmission with many speeds

is extremely large. Second, there is no certainty that the gearset selected is actually the best of all possible schemes.

This article presents basic facts about planetary gear trains in a form that will help the designer to take the shortest way to initial selection of a basic gearset. Discussion is limited to consideration of only one factor—simplicity of basic arrangement.

Most planetary transmissions today have planet pinions meshed with internal ring gears. The main advantages of this type are relatively high efficiency and convenience of braking the ring gear. This discussion considers only planetary transmissions of this type. Throughout the discussion, capital letters identify individual members of trains.

**Simple Train Speed Ratios and Limitations:** A simple planetary unit of the internal-gear type is presented in Fig. 1. One of three shafts in this unit is the driver, another is the follower, and the third shaft is fixed. There are seven possible conditions of operation, and expressions for the speed ratios for this arrangement, Table 1. Conditions 1 and 2 may be used when the unit is employed as a reducer with a positive speed ratio, Conditions 5 and 6 for speed ratios less than unity, Conditions 3 and 4 when a reversal of rotation is needed, and Condition 7 when the speed ratio must equal unity. However, the driving and driven members in a transmission are usually predetermined. Therefore, the number of ratios which can be obtained with a gearset of this type is two: Condition 1, when shaft *N* is the driver and shaft *M* is the follower; and Condition 7, when the entire unit is locked together. These two ratios can be obtained with

Fig. 2 — Compound planetary train with ring gears. Each of two sun gears, each of two ring gears, and the carrier may be connected either to the driving shaft or to the driven shaft.

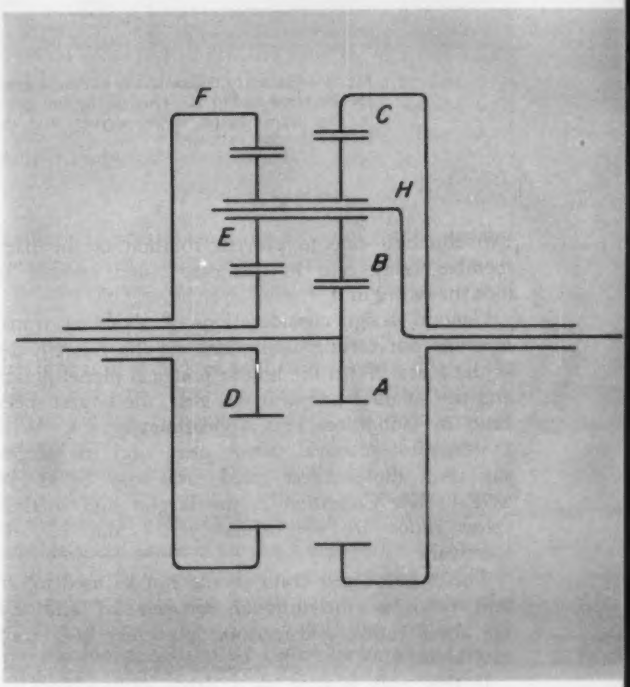



**Table 1—Speed Ratios Obtainable from a Simple Planetary Train, Fig. 1**

| Condition | Shaft *N* (Sun Gear) | Shaft *M* (Carrier) | Shaft *L* (Ring Gear) | Speed Ratio Equation | Equation No. |
|---|---|---|---|---|---|
| 1 | driver | follower | fixed | $r_1 = 1 + \frac{c}{a}$ | (1) |
| 2 | fixed | follower | driver | $r_2 = 1 + \frac{a}{c}$ | (2) |
| 3 | follower | fixed | driver | $r_3 = -\frac{c}{a}$ | (3) |
| 4 | driver | fixed | follower | $r_4 = -\frac{a}{c}$ | (4) |
| 5 | follower | driver | fixed | $r_5 = \frac{a}{a+c}$ | (5) |
| 6 | fixed | driver | follower | $r_6 = \frac{c}{a+c}$ | (6) |
| 7 | Entire system locked | | | $r_7 = 1$ | .... |

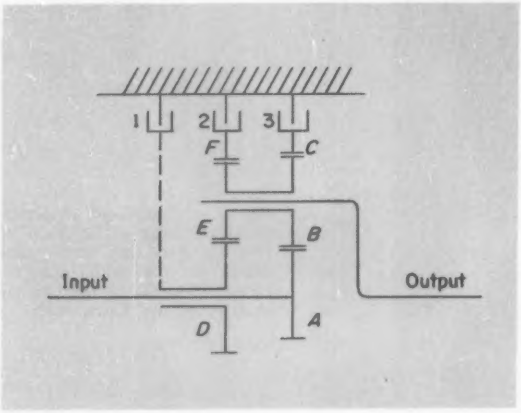



Fig. 3—Planetary transmission having a gear-set the same as Fig. 2. One of the sun gears in this transmission is the driver, and the carrier is the follower.

two clutches—one to prevent rotation of the fixed member (ring gear in this case), and another to lock the entire unit.

General design considerations of planetary transmissions put certain limitations on the relative size of the gears. With the largest practical planet pinion and the smallest practical sun gear, the largest speed ratio in Condition 1 is approximately 4.4. With the smallest practical planet gear, and the largest sun gear, the smallest speed ratio may be as low as 2.4. For Condition 2, the largest and smallest speed ratios are approximately 1.7 and 1.3, respectively.

This type of gear train should not be used to obtain ratios in the interval between 1.7 and 2.4. For these ratios, a compound planetary gear train may be used.

If this unit is used as a drive with a negative speed ratio (reverse), Conditions 3 and 4, the possible speed ratios will lie between $-0.3$ and $-0.7$, and between $-1.4$ and $-3.3$.

**Compound Train with Ring Gears:** One arrangement of this type is shown in Fig. 2. Each of two sun gears *A* and *D*, ring gears *C* and *F*, and carrier *H* may be connected either to the driving shaft or to the driven shaft. This gives a large number of possible trains. Each train has a number of possible speed ratios and other characteristics.

Assume that sun gear *A* is connected to the driving shaft, while the planet carrier is connected to the driven shaft. One of three gears, *D*, *C*, or *F* may be prevented from rotation by some kind of brake or clutch, Fig. 3.

If clutch 3 is engaged, and clutches 1 and 2 are disengaged, the speed ratio of this train, consisting of gears *A*, *B*, *C*, etc., is $r_1$, Equation 1, Table 1. In this and subsequent equations, letters *a*, *b*, *c*, etc. . . . stand for the number of teeth in gears *A*, *B*, *C*, etc. If only clutch 2 is engaged, the train consists of gears *A*, *B*, *E*, and *F*, and its speed ratio is:

$$r_2 = 1 + \frac{bf}{ae} \qquad (7)$$

If only clutch 1 is engaged, the train consists of gears *A*, *B*, *E*, and *D*, and the speed ratio of this train is:

$$r_3 = 1 - \frac{bd}{ae} \qquad (8)$$

If, in addition to clutches 1, 2, and 3, there is a device which permits all gears of this assembly to be locked together, the speed ratio equals unity, $r_4 = 1.0$.

Therefore, this arrangement provides four possible speed ratios. Two are positive and greater than unity, one is equal to unity, and one may be either positive and less than unity or it may be negative.

**Compound Train with Additional Idler Planets:** A unit similar to one just discussed, but with a set of additional planet pinions, is shown in Fig. 4. This set of idler planets, gear *K* in Fig. 4, may per-

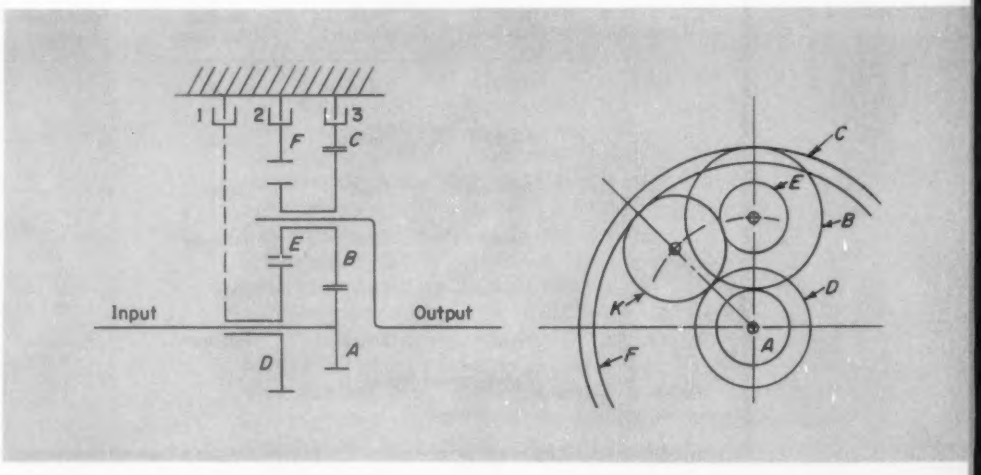



Fig. 4—Compound planetary train with additional set of idler planets.

mit more suitable combinations of speed ratios to be obtained.

In this train, if clutch 3 is engaged, and other clutches are disengaged, the speed ratio is $r_1$, Equation 1.

If only clutch 1 is engaged, the ratio is:

$$r_2 = 1 + \frac{bd}{ae} \tag{9}$$

If only clutch 2 is engaged:

$$r_3 = 1 - \frac{bf}{ae} \tag{10}$$

If the entire gearset is locked together, the speed ratio equals unity, $r_4 = 1.0$. When none of the clutches are engaged, all gears are idling and the drive is in neutral. This arrangement may be used as a complete transmission having three speeds forward, one speed in reverse, and a neutral position. Such a transmission, the Allison Torqmatic, is shown in the illustration at the head of this article.

**Compound Train from Combined Simple Trains:** Two simple units can be built into one train in such a way that the plant carriers of both simple units are connected to the same shaft, and the ring gear of the first unit is connected to the sun gear of the second unit, Fig. 5.

This gearset gives three speed ratios—two forward and one in reverse: If only clutch 1 is engaged, the speed ratio is $r_1$, Equation 1; if the train is locked together, the ratio is unity, $r_2 = 1.0$; and if only clutch 2 is engaged,

$$r_3 = 1 - \frac{cf}{ad} \tag{11}$$

Since c and $f$ are greater than $a$ and $d$, $r_3$ is negative, and the unit is in reverse.

This gear train is well suited for relatively large negative ratios. Each planet has its own planetary axis, therefore $(a+b)$ need not equal $(d+e)$, as in the two earlier examples. This permits more freedom in selecting the diameters of the individual gears. Thus, the desired speed ratios may be more easily achieved than in the two previous designs.

**Combined Multiple Trains:** Planetary transmissions having relatively large numbers of speed ratios (more than four, including reverse) may be designed using several connected trains, simple or compound.

The maximum theoretical number of speed ratios for the entire transmission is the product of the number of speed ratios of individual units.

Thus, in a transmission consisting of three individual planetary units, the number of speed ratios which can be obtained by means of the first unit is $n_1$, the corresponding number of the second unit is $n_2$, and that for the third unit is $n_3$. The maximum number of possible speed ratios is

$$N = n_1 \times n_2 \times n_3$$

Similarly, a transmission consisting of two compound planetary units, having four and three speed ratios, respectively, will have a maximum of twelve speed ratios.

However, if more than one of the speed ratios of the first unit coincides with the speed ratios of the second unit, the possible number of speed ratios of the transmission becomes smaller. For example, a transmission consists of two compound planetary units having four and three speed ratios. But three ratios of the first unit are the same as three ratios of the second unit. Consequently, the number of possible speed ratios of such a transmission is reduced to nine. If three of the four ratios of the first unit are positive while the fourth ratio is negative, and all three ratios of the second unit are positive, this transmission can have six ratios forward and three in reverse.

**Gear Diameters of a Compound Train:** The train in Fig. 3 is used to illustrate the procedure for

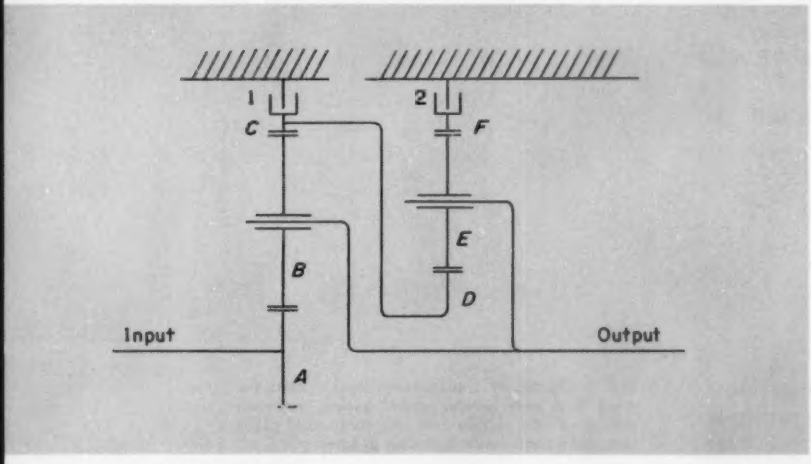



Fig. 5 — Compound planetary train which is a combination of two simple planetary units built into one gearset.

finding gear diameters in a compound train. The same approach applies to any other compound train.

If, as is usual, there are two or more planet gearsets in a planet unit, the number of teeth in the sun gear, planet, and ring gear must have certain relations to each other to make proper assembly of the train possible. However, to simplify the preliminary selection of gear diameters, the limitation of tooth numbers with respect to assembly conditions is disregarded. Hence, the number of teeth in individual gears will be considered only as a function of gear diameters. Any adjustment in numbers of teeth needed to satisfy the assembly conditions must be done in the final stage of design.

Three speed ratios, and the ratio equal to unity, can be obtained from the gearset in Fig. 3. The three ratios are expressed by Equations 1, 7, and 8. Assume that the following ratios are required: $r_1 = 4.8$ to 5.0, $r_2 = 6.4$ to 6.6, $r_3 = -1.4$ to $-1.6$, $r_4 = 1.0$, and neutral position of the drive.

From the average value for assumed speed ratios, the required gear diameters can be determined by solving together the equations:

$$r_1 = 1 + \frac{d}{a} = 4.9$$

$$r_2 = 1 + \frac{bf}{ae} = 6.5$$

$$r_3 = 1 - \frac{bd}{ae} = -1.5$$

$$c = a + 2b$$

$$f = d + 2e$$

$$a + b = d + e$$

From the equations for $r_2$ and $r_3$, $f/d = 2.2$.

Assume initially that the number of teeth in the ring gear $F$ is 90 ($f = 90$). This number may be changed later if necessary. Then, $d = 90/2.2 = 40.9$. Say $d = 42$. From the above equations, $e = (f - d)/2 = (90 - 42)/2$, and $a + b = 42 + 24 = 66$.

Then, $a + 2b = 3.9a$, and $b = 1.45a$. Since $a + b = 66$, $a = 66/2.45 = 26.9$, say 27. Then, $b = 66 - 27 = 39$, and $c = 27 + (39 \times 2) = 105$. The resulting tooth numbers are: $a = 27$, $b = 39$, $c = 105$, $d = 42$, $e = 24$, and $f = 90$.

A check of speed ratios shows agreement with objective ratios:

$$r_1 = 1 + \frac{105}{27} = 4.9$$

$$r_2 = 1 + \frac{39 \times 90}{27 \times 24} \approx 6.4$$

$$r_3 = 1 - \frac{39 \times 42}{27 \times 24} \approx -1.53$$

It is often impossible to obtain all three speed ratios within the desired limits from any particular planetary train. Sometimes even two out of three desirable ratios cannot be obtained. The ratios may be possible to obtain, but the diameters of certain gears may become inconvenient (too small or too large). In these cases, additional gears may be added to the assembly, or other types of planetary trains, or combinations of planetary trains must be used.

**Transmission Having More Than One Unit:** Assume that a transmission must have four ratios forward: 12.0, 6.0, 3.0, and 1.0; and two ratios in reverse: One between $-7$ and $-8$, and another between $-2.5$ and $-3.0$.

Two planetary units will be sufficient to obtain the needed ratios—one with three ratios, the other with two. It can be seen that the simplest combination for the forward motion is ratios of 4, 2, and 1 for one unit, and 3 and 1 for the second unit. In addition to these ratios, one of the units must have a negative speed ratio for reverse. The required ratios may be obtained thus:

1st speed ratio $r_1 = 12 = 4 \times 3$
2nd speed ratio $r_2 = 6 = 2 \times 3$
3rd speed ratio $r_3 = 3 = 1 \times 3$
4th speed ratio $r_4 = 1 = 1 \times 1$
1st in reverse $R_1 = ? = R \times 3$
2nd in reverse $R_2 = ? = R \times 1$

Assume that the first unit will be a compound train with three positive ratios: $\alpha = 4.0$, $\beta = 2.0$,

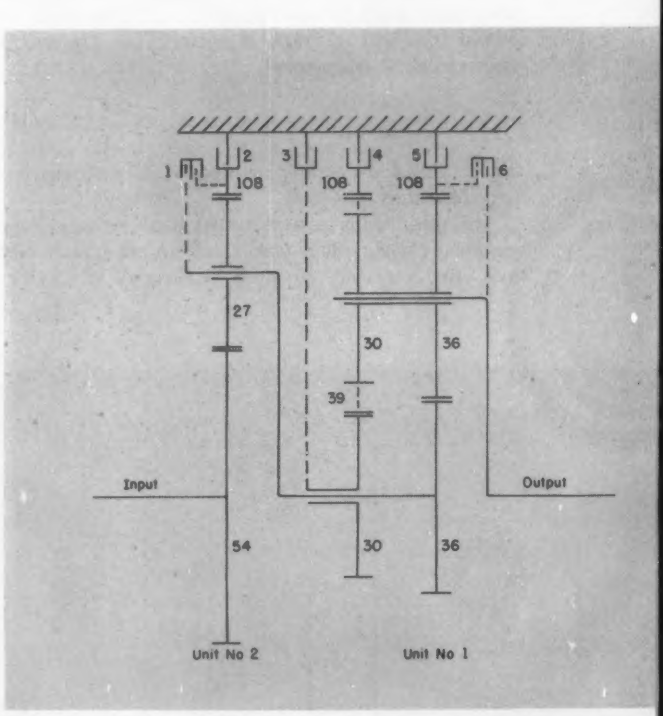



Fig. 6—Planetary transmission having four forward and two reverse speed ratios, and consisting of one simple and one compound planetary gear train built into one gearset.

and $\gamma = 1.0$, and one negative ratio, $R$. Then, the second unit may be a simple planetary train having two positive ratios: $x = 3.0$, and $y = 1.0$. The ratios $\gamma = 1.0$ and $y = 1.0$, in both units, will be obtained by locking the gear system together. Assume that the assembly of the first unit corresponds to the train shown in Fig. 4. Then, from Equation 1, $\alpha = 4 = 1 + c/a$. Hence, $c = 3a$. Since $c = a + 2b$, $3a = a + 2b$, and $a = b$. From Equation 9, $\beta = 2 = 1 + bd/ae$. Hence, $bd/ae = 1.0$. Since $a = b$, it follows that $d/e = 1.0$ and $d = e$. Assume $a = 36$ and $b = 36$, then $c = a + 2b = 108$. Gear $E$ is not engaged with gear $D$ in this train, and $(e + d) < (a + b)$. Assume $e = 30$ and $d = 30$. There is some advantage in designing ring gears $C$ and $F$ of approximately the same diameter. Therefore, assume a preliminary $f = c = 108$. Then from $f = 108 = d + 2k = 30 + 2k$, $k = 39$. The value of the speed ratio in reverse can be determined from substitutions in Equation 10:

$$R = 1 - \frac{bf}{ae} = 1 - \frac{36 \times 108}{36 \times 30} = -2.6$$

This ratio is within the required limits for one of the ratios in reverse.

For the second unit, the simple planetary gear train shown in Fig. 1 may be used. Shaft $N$ will be the driver and shaft $M$, connected to the planet carrier, will be the follower. From Equation 1, $x = 3 = 1 + c'/a'$. Hence, $c' = 2a'$, and for assembly, $c' = 2b' + a'$. Therefore, $a' = 2b'$. Since the ring gear $C'$ is assumed to have the same diameter as gears $C$ and $F$ of the first unit, $c' = 108$. Then $108 = 2b' + a' = 4b'$, and $b' = 27$ and $a' = 54$. The possible speed ratios which can be obtained by a transmission consisting of these two planetary units are presented in Table 2. The general scheme of this transmission is shown in Fig. 6.

**Table 2—Speed Ratios for a Transmission Having Two Combined Units**

| Second Unit Ratios | First Unit Ratios | | | |
|---|---|---|---|---|
| | $\alpha = 4.0$ | $\beta = 2.0$ | $\gamma = 1.0$ | $R = -2.6$ |
| $x = 3.0$ | $\alpha x = 12$ | $\beta x = 6$ | $\gamma x = 3$ | $Rx = -7.8$ |
| Clutches Engaged | 2 and 5 | 2 and 3 | 2 and 6 | 2 and 4 |
| $y = 1.0$ | .... | .... | $\gamma y = 1$ | $Ry = -2.6$ |
| Clutches Engaged | .... | .... | 1 and 6 | 1 and 4 |

Notes: Ratios $\alpha y$ and $\beta y$ are not used for conditions assumed in this example. In "Clutches Engaged" lines, numbers identify clutches in Fig. 6.

If a transmission having these same speed ratios is made up of several simple planetary trains, it seems at first glance that four such simple units will be sufficient. Three units having 3 and 1, 2 and 1, and 2 and 1 speed ratios will produce the needed positive ratios 12, 6, 3, and 1. An additional simple unit can be used for reverse. However, such a transmission will need eight clutches—four to produce ratios 3, 2, 2 and reverse, and four more rotating clutches to lock each unit together. Such a transmission will also require four individual planet carriers.

Actually, a speed ratio equal to 2 is practically impossible to achieve by a simple planetary train. Therefore, even four simple trains are not sufficient to produce six ratios assumed for this problem.

**Transmission Having Five Speeds Forward; Two or Three in Reverse:** A gearset having five forward

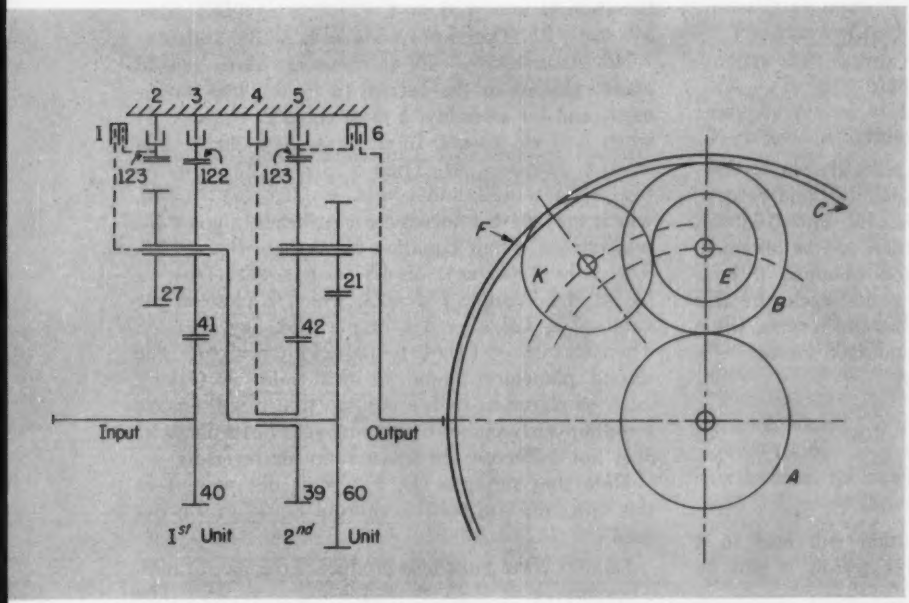
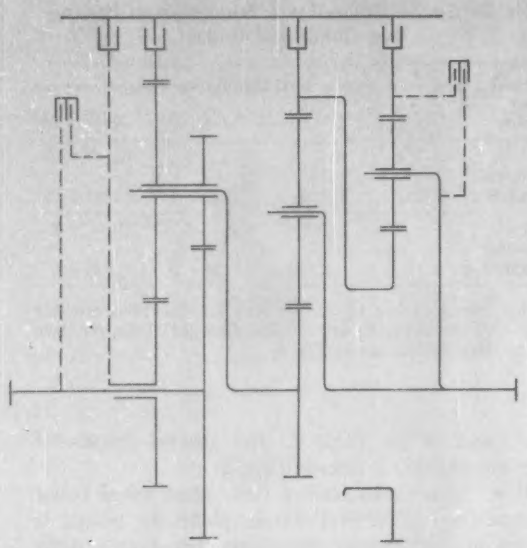
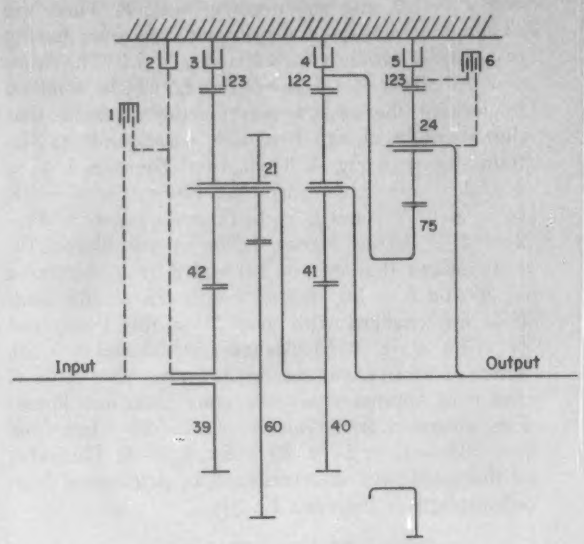



Fig. 7—Planetary transmission having five forward and three reverse speed ratios, and consisting of two compound planetary trains built into one gearset.



| Ratios | $\alpha = 2.025$ | $\beta = 1.00$ | $\gamma = 0.675$ |
|---|---|---|---|
| $x = 4.12$ | 8.35 | 4.12 | .... |
| $y = 1.00$ | 2.025 | 1.00 | 0.675 |
| $R = -4.1$ | −8.3 | −4.1 | −2.77 |

Fig. 8—Planetary transmission having about the same speed ratios as the transmission in Fig. 7, but with a different gear arrangement.




| Ratios | $\alpha = 2.025$ | $\beta = 1.00$ | $\gamma = 0.675$ |
|---|---|---|---|
| $x = 4.05$ | 8.2 | 4.05 | .... |
| $y = 1.0$ | 2.025 | 1.00 | 0.675 |
| $R = -4.0$ | −8.1 | −4.0 | −2.7 |

Fig. 9—Planetary transmission having speed ratios close to those in the transmissions in Fig. 7 and 8.

speeds and two or three in reverse is to be selected. The desirable five positive ratios are 8.25, 4.08, 2.02, 1.00, and 0.68.

These ratios may be obtained by the following combinations:

$r_1 = 8.25 = 4.08 \times 2.02$, or $2.02 \times 4.08$
$r_2 = 4.08 = 4.08 \times 1.0$, or $2.02 \times 2.02$, or $1.0 \times 4.08$
$r_3 = 2.02 = 2.02 \times 1.0$, or $1.0 \times 2.02$
$r_4 = 1.0 = 1.0 \times 1.0$
$r_5 = 0.68 = 0.68 \times 1.0$, or $1.0 \times 0.68$

Consequently, if two planetary units are employed—one having four ratios, 4.08, 2.02, 1.0, and reverse, and another having ratios 2.02, 1.0, and 0.68—all required ratios for the transmission can be obtained.

The same result may be also obtained if both units have only three speed ratios each. In this case, one unit must have 4.08, 1.0, and reverse, while another will have 2.02, 1.0, and 0.68 ratios.

The needed forward ratios are:

$r_1 = 4.08 \times 2.02 = 8.25$
$r_2 = 4.08 \times 1.00 = 4.08$
$r_3 = 1.0 \times 2.02 = 2.02$
$r_4 = 1.0 \times 1.0 = 1.0$
$r_5 = 1.0 \times 0.68 = 0.68$

It seems that the second solution will lead to a simpler gear train, and for this reason it will be chosen.

First Unit must produce three ratios: $x = 4.08$, $y = 1.00$, and $R$ (negative ratio for reversing). If the type of assembly corresponds to the scheme in Fig. 4, Equations 1, 9, and 10 must be used. From Equation 1, $x = 4.08 = 1 + c/a$; $c = 3.08a$. Also, $c = a + 2b$. Therefore, $3.08a = a + 2b$, and $b = 1.04a$. Assume $a = 40$. If there are three sets of planet pinions in the carrier $(a - 1)/3 = m$ integer, and for assembly, $b$ must equal $2 + (n \times 3)$ when $n$ is an integer. In this case $b = 40 \times 1.04 = 41.6$. Say $b = 41$. Then $c = a + 2b = 40 + (41 \times 2) = 122$, and $x = 1 + (122/40) = 4.05$, which may be considered as a sufficiently good approximation. From Equation 10, assume $R \approx -3.5$, $3.5 = 1 - (bf/ae)$, or $4.5 = (41/40)\ (f/e)$, or $f/e \approx 4.4$. Assume $f = 123$, which is close to the value of $c$, $123/e = 4.4$, or $e \approx 28$. Say $e = 27$. Then $R = 1 - (41/40)\ (123/27) = -3.67$. The second planetary pinion in this train, $K$ (idler), must be placed in such a position that it will engage simultaneously planet $E$ and ring gear $F$. Its diameter does not influence the speed ratio for reverse.

Note that sun gear $D$, Fig. 4, is not present in this unit, and the possible ratio of Equation 9 is not used.

Second Unit must also produce three speed ratios. They are: $\alpha = 2.02$, $\beta = 1.0$ and $\gamma = 0.68$. The

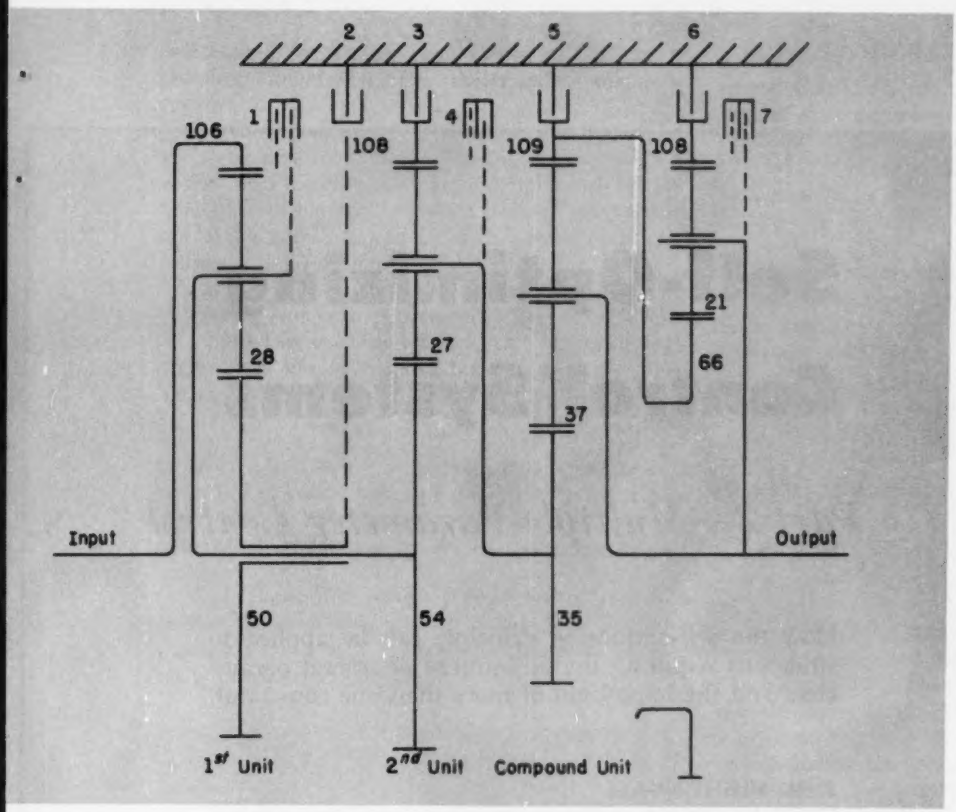



Fig. 10—Planetary transmission having six forward and three reverse speed ratios, and consisting of one compound and two simple planetary units.

assembly similar to Fig. 3 is chosen. Equations 7 and 8 may be used. From Equation 7, $\alpha = 2.02 = 1 + (b'f'/a'e')$, and from Equation 8, $\alpha = 0.68 = 1 - (b'd'/a'e')$. From these equations, $b'f'/a'e' = 1.02$ and $b'd'/a'e' = 0.32$. Division of one by the other yields $f'/d' = 1.02/0.32 \approx 3.19$, or $f' = 3.19d'$. Also, $f' = d' + 2e'$, $e' = 1.095d'$, and $d'/e' = 2/2.19$. Therefore, $b'd'/a'e' = 0.32 = (2/2.19)(b'/a')$, $b'/a' = 0.35$, and $a' = 2.86b'$. Assume $b' = 21$. Then, $a' = 2.86 \times 21 = 60$. Also, $a' + b' = 81 = d' + e'$, $d' + 1.095d' = 81$, and $d' \approx 38.6$. Say $d' = 39$. Then $e' = 81 - 39 = 42$, and $f' = 39 + (42 \times 2) = 123$. (Note that ring gear $C$ is not needed in this train.) Check the speed ratios: $\alpha = 1 + (21/60)(123/42) = 2.025$, and $\gamma = 1 - (21/60)(39/42) = 0.675$. The possible speed ratios which can be obtained by this transmission are presented in Table 3. From the speed ratios available, the ratio $\gamma x = 2.74$ will not be used. The ratios in the table compare closely with the ratios initially assumed.

**Table 3—Speed Ratios for a Transmission Having Multiple Speeds Forward and Reverse**

| First Unit Ratios | Second Unit Ratios | | |
|---|---|---|---|
| | $\alpha = 2.025$ | $\beta = 1.00$ | $\gamma = 0.675$ |
| $x = 4.05$ | $\alpha x = 8.2$ | $\beta x = 4.05$ | $\gamma x = 2.74$ |
| $y = 1.00$ | $\alpha y = 2.025$ | $\beta y = 1.00$ | $\gamma y = 0.675$ |
| $R = 3.67$ | $\alpha R = -7.44$ | $\beta R = -3.67$ | $\gamma R = -2.48$ |

The kinematic scheme of the entire transmission is presented in Fig. 7. The advantages of this gear train are: 1. Relative simplicity. 2. Both rotating clutches may be placed at the ends of the transmission. 3. Very good efficiency for all forward speeds. 4. All planet pinions are of relatively small diameters—important in the design of planet carriers. A disadvantage is that the ring gears in the train are somewhat too large. This is due to a rather awkward combination of speed ratios in the second planetary unit (2.025 and 0.675).

In Figs. 8 and 9 the kinematic schemes of two more transmissions are shown. The speed ratios of these transmissions also closely approximate the ratios assumed initially for this problem. The transmission shown in Fig. 10 has somewhat different speed ratios. This transmission is able to produce six forward speed ratios, 12.36, 6.04, 4.12, 3.0, 1.47, and 1.0, as well as three ratios in reverse, −12.3, −6.03, and −4.1. The same general method as was used in the previous examples was also applied for developing these kinematic schemes.

# Self-Optimizing Control Systems

## *Part 2—Multiple-Parameter Control*

**How the self-optimizing principle can be applied to situations requiring the adjustment of several parameters and the imposition of more than one constraint.**

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USE of subsidiary loops for automatic setting of control-system parameters at their optimum values was discussed in Part 1 of this series. Perturbations, deliberately introduced in an adjustable parameter, are reflected in the measured mean-square of error $E(\lambda, t)$. These perturbations are detected by selective and phase-sensitive filters. The resulting signal is used either to increase or decrease the parameter until a steady-state condition at (or near) the optimum condition is reached.

Although the adjustment of parameters by this method is not new, the principle can be extended conveniently to include the situation in which constraints on system variables are included as design criteria.[1,2] This precaution is often necessary in control systems. It provides a safeguard against

[1]References are tabulated at end of article.

**Nomenclature**

| | |
|---|---|
| $C_i$ | = Desired limit on mean square value of system variables |
| $E$ | = Mean square of error |
| $F(p)$ | = Transfer function of tuned filter |
| $G(p)$ | = Transfer function of control device |
| $K$ | = System constant |
| $m(t)$ | = Demodulating signal |
| $p$ | = Differential operator, $d/dt$ |
| $t$ | = Time variable |
| $W$ | = Mean square value of system variables |
| $\lambda$ | = System parameter |
| $\Omega$ | = Perturbation frequency |

overloading the system components, as well as a practical foundation for theoretically optimum systems.

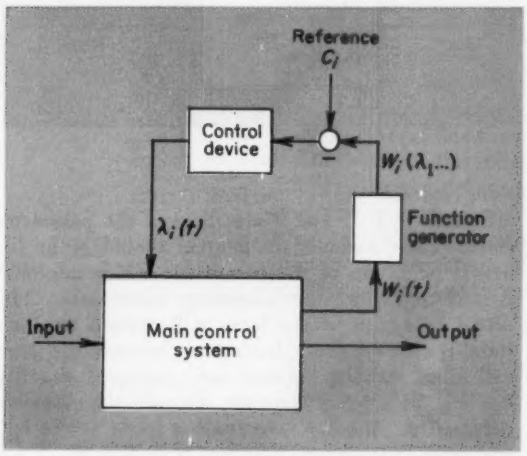
A system involving two parameters, adjusted by an optimizing loop and a constraint loop, is discussed in Reference 3. The principle can be extended to situations in which several parameters are to be adjusted, and in which more than one constraint is to be imposed.

Consider $\lambda$ as a parameter to be adjusted by an optimizing loop, and $n$ parameters $(\lambda_1, \cdots \lambda_n)$ to be adjusted by constraint loops. Thus, $n$ constraints are imposed on $n$ system variables $(w_1, w_2, \cdots w_n)$. This may be written

$$W_i(\lambda_1, \ldots \lambda_n) = C_i$$

where $i = 1, 2, \cdots n$ and $W_i(\lambda_1, \cdots)$ represents the measured value of that function of $w_i(t)$ (for instance, its mean-square) which is to be constrained. Desired limit on $W_i$ is represented by $C_i$.

**Main Constraint Loops:** A measure of the difference between $W_i$ and $C_i$ is used to monitor parameter $\lambda_i$, Fig. 7. Thus, the equations of the main constraint loops are




$$\lambda_i(t) = G_i(p)[W_i(\lambda_1, \ldots) - C_i] \qquad (2)$$

where $G_i(p)$, $G_2(p)$, $\cdots$ are the transfer functions of the control device and any necessary smoothing filters in the respective loops. The mean squares, $W_1$, $W_2$, $\cdots$ are obtained by passing the respective system variables through appropriate function generators.

**Subsidiary Constraint Loops:** The optimum condition is determined by the minimum of the measured mean-square of error $E(\lambda, \lambda_1, \cdots)$. The necessary condition is

$$\frac{\partial E}{\partial \lambda} + \sum_{j=1}^{n} \frac{\partial E}{\partial \lambda_j} \frac{\partial \lambda_j}{\partial \lambda} = 0 \qquad (3)$$

where $\partial\lambda_j/\partial\lambda$ is obtained from

$$\frac{\partial W_i}{\partial \lambda} + \sum_{j=1}^{n} \frac{\partial W_i}{\partial \lambda_j} \frac{\partial \lambda_j}{\partial \lambda} = 0 \qquad (4)$$

where $i = 1, \cdots n$.

The conditions of Equations 3 and 4 are to be forced upon the system by means of feedback in the parameter loops. To do this, a perturbation, $\delta\lambda(t)$, of frequency $\Omega$, which may for convenience, have a sinusoidal or rectangular waveform is added to parameter $\lambda$. Also, perturbations $\delta\lambda_1(t)$, $\delta\lambda_2(t)$, $\cdots$ at the same frequency are to be induced in the parameters $\lambda_1$, $\lambda_2$, $\cdots$. Therefore, the total perturbation in $W_i(\lambda_1, \cdots)$ at frequency $\Omega$ is

$$\frac{\partial W_i}{\partial \lambda} \delta\lambda(t) + \sum_{j=1}^{n} \frac{\partial W_i}{\partial \lambda_j} \delta\lambda_j(t)$$

This component can be picked out by passing the square of $W_i(t)$ through a filter tuned at frequency $\Omega$, Fig. 8. The output of the filter is used to monitor the perturbation, $\delta\lambda_i(t)$ by means of a subsidiary constraint loop, Fig. 9. A total of $n$ such loops must be available to induce all the required perturbations. The equations of these loops are

Fig. 7 — Above — Constraint loop used to control parameter $\lambda_i$. The control device is operated by a signal which is a measure of the difference between the desired and actual values of the constraint.

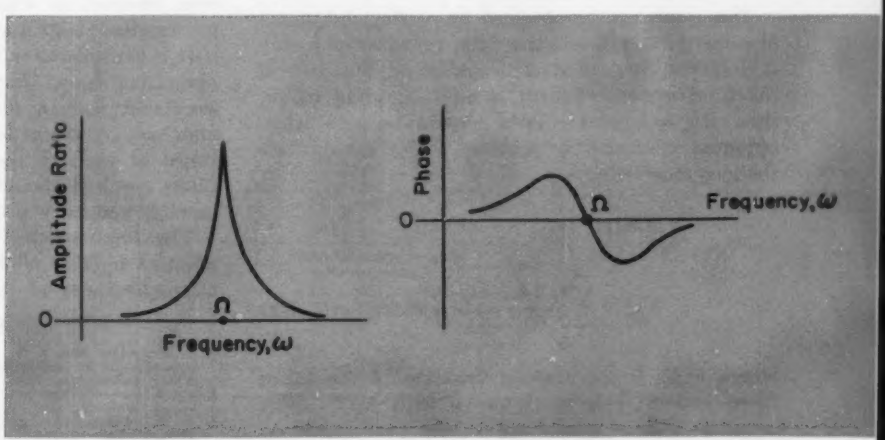



Fig. 8—Right—Characteristics of the filter used to measure the perturbation in $W_i(\lambda, \ldots)$ at frequency $\Omega$. The output of the filter is used to monitor the parameter perturbation $\delta\lambda_i(t)$.

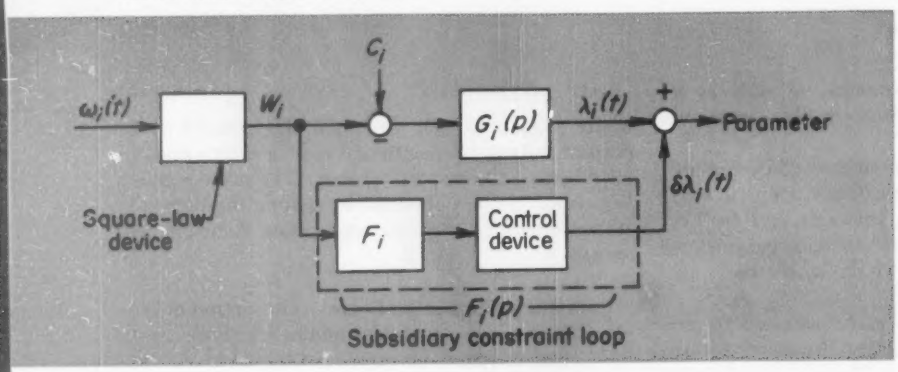



Fig. 9—Left—How a subsidiary loop is used in conjunction with each constraint loop to induce the required perturbation in the parameter being monitored.

Fig. 10—Below—Optimizing parameter loop. The perturbation in the mean-square error is picked out by the filter. Its phase relative to perturbation $\delta\lambda(t)$ is obtained from the product demodulator. The output of the demodulator monitors by means of a control device, which can be an integrating motor.

$$\delta\lambda_i(t) = F_i(p)\left[\frac{\partial W_i}{\partial\lambda}\delta\lambda(t) + \sum_{j=1}^{n}\frac{\partial W_i}{\partial\lambda_j}\delta\lambda_j(t)\right] \quad (5)$$

where $F_1(p)$, $F_2(p)$, $\cdots$ are the transfer functions of the subsidiary loops. If the gain of each of these loops can be made large at frequency $\Omega$, then the following relations are imposed on the induced perturbations:

$$\delta\lambda_i(t) = \frac{\partial\lambda_i}{\partial\lambda}\delta\lambda(t) \quad (6)$$

**Optimizing Loop:** The total perturbation in $E(\lambda, \lambda_1, \cdots)$ at frequency $\Omega$ is

$$\delta E(t) = \frac{\partial E}{\partial\lambda}\delta\lambda(t) + \sum_{j=1}^{n}\frac{\delta E}{\partial\lambda_j}\delta\lambda_j(t) \quad (7)$$

Substituting from Equation 6,

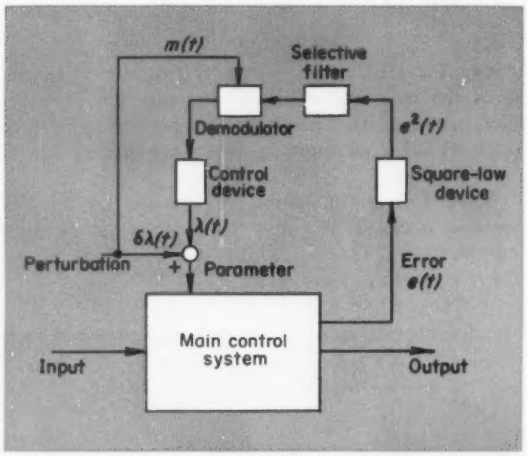
$$\delta E(t) = \left[\frac{\partial E}{\partial\lambda} + \sum_{j=1}^{n}\frac{\partial E}{\partial\lambda_j}\frac{\partial\lambda_j}{\partial\lambda}\right]\delta\lambda(t) \quad (8)$$

A comparison of Equation 8 and Equation 3 shows that if $\delta E(t)$ is detected, its phase will change sign relative to $\delta\lambda(t)$ as it passes through the optimum point. Thus, by passing perturbation $\delta E(t)$ through a phase-sensitive detector, a signal can be obtained which can be used to monitor $\lambda$.

This result can be obtained by passing the square of error through a selective filter tuned at frequency $\Omega$, followed by a product demodulator, Fig. 10.[3] If the final control element is an integrating motor, then the steady-state error should be zero when optimum condition is achieved. The equation of the loop monitoring $\lambda$ is

$$\frac{d\lambda}{dt} = -Km(t)F(p)\left[\frac{\partial E}{\partial\lambda}\times\sum_{j=1}^{n}\frac{\partial E}{\partial\lambda_j}\frac{\partial\lambda_j}{\partial\lambda}\right]\delta\lambda(t) \quad (9)$$

where $F(p)$ is the transfer function of the tuned filter, and $m(t)$ is synchronized with $\delta\lambda(t)$. This equation will be considered in the next article by




using suitable approximations.

Equations 2, 5, and 7 are those of the parameter loops. Their steady-state solution should be at (or near) the values of the parameters which minimize $E$ and maintain the necessary constraints. The actual operation of the loops will depend on their stability characteristics. Interaction between the loops will affect stability because each measured quantity $E$, $W_1$, $W_2$, $\cdots$ depends on all the variable parameters. Another deteriorating factor is the fact that only approximate measures of $E$, $W_1$, $W_2$, $\cdots$ are possible. These measures are subjected to random fluctuations which will cause the parameters to wander about the desired values.

It is possible to minimize $E$ with more than one optimizing loop. Each optimizing loop must be associated with a distinct perturbation frequency, and each constraint loop must have subsidiary loops tuned at each of these frequencies. The selective filters required should not have substantially overlapping frequency responses.

**The final article** in this series will discuss the effect of stability of the parameter loops upon overall performance of the system.

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# NORMAL ERROR

## *for common mathematical functions*

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IN engineering applications of statistics, mathematical expressions often occur in which one variable, or more, is subject to random error. And a standard deviation, $\sigma$, can usually be determined for each variable. The problem, then, becomes to compute the resulting standard deviation when the form of the function and the $\sigma$ values for the individual variables are known.

For instance, in a product relationship like voltage equal to current times resistance ($E = IR$) the standard deviation of the voltage is made up of the standard deviations of the current and resistance, as partial products squared—in other words, $\sigma_E = (I^2\sigma_R{}^2 + R^2\sigma_I{}^2)^{1/2}$. Table 1 provides typical ways to combine the standard deviations of two variables into a composite standard deviation. It is easy to prepare simi-

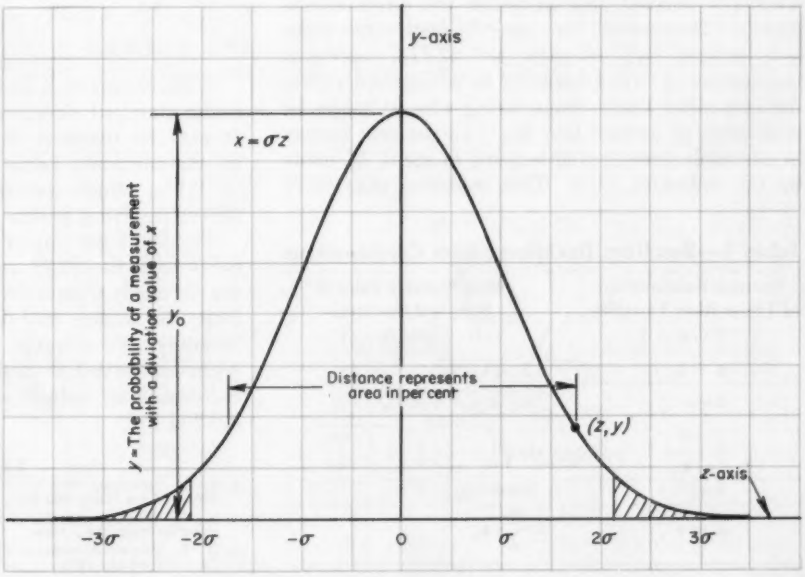



Fig. 1 — Symmetrical probability curve for which the total area under the curve represents 100 per cent

## Probability Curve Relationships

Random errors fall in a frequency distribution bounded by the Gussian or normal probability curve, Fig. 1. The coordinates to a point on the curve are $z$ and $y$, with the $y$-axis passing through the crest of the curve.

Suppose $r$ is any one of a great number of readings or variable measurements $n$. In accord with statistical methods, the arithmetic mean of the readings is

$$\bar{r} = \frac{\Sigma r}{n}$$

an individual deviation $x$ measured from the mean is

$$x = r - \bar{r}$$

and the standard deviation $\sigma$ is

$$\sigma = \sqrt{\frac{\Sigma x^2}{n}}$$

Units of standard deviation are measured along the horizontal axis in such a way that $z = x/\sigma$. An ordinate measured along the $y$-axis represents the probability of a measurement with a deviation value of $x$. The equation of the curve is often expressed in different forms depending upon which parameters are known and unknown for specific applications.

The area under the error curve represents all of the deviations. It can be taken as unity or 100 per cent. This makes any partial area bounded by the curve and any two ordinates directly proportional to the distance between the ordinates. Any such area between ordinates $\pm z$ can be computed from

$$A = \frac{100}{\sqrt{2\pi}} \int_{-z}^{z} e^{-z^2/2}\, dz$$

These areas will be found in tables in most any textbook on statistical methods[1,2,3] and in handbooks. For present purposes, the area under the curve between ordinates at $\pm 2\sigma$ is 95.46 per cent, that at $\pm 2.11\sigma$ is 96.51 per cent, that at $\pm 3\sigma$ is 99.73 per cent, and that at $\pm \infty$ is 100 per cent.

lar relationships when more than two variables are involved.

**Example:** Suppose the section modulus of a member loaded in bending is a matter for investigation. Let the mean value of the allowable stress be 10,000 psi with a total error of $\pm 10$ per cent because of irregularities in manufacture. The bending-moment mean value is 50,000 lb-in. with a total error of $\pm 10$ per cent because of uncertainties in loading.

In the application of normal error theory, a certain percentage of the values (readings, measurements, trials, combinations, and so on) is assumed as exceeding the limits of normal expectancy. This percentage may be chosen arbitrarily small, nonetheless it exists. The crosshatched area, Fig. 1, represents any selected area in which the errors exceed normal. Conversely, the area beneath the curve and between two ordinates, as $\pm 2.11\sigma$, represents the number of values normally to be expected within the prescribed limits. Engineering-wise, it might be reasonable to assume that the $\pm 10$ per cent leeway in allowable stress, $s$, and bending moment, $M$, apply to the ordinates, $\pm 3\sigma$. This indicates that 99.73 per cent would fall within the limits for either variable. Accordingly, the standard individual deviations would be

$$\sigma_s = \frac{1000}{3} = 333 \text{ psi}$$

$$\sigma_M = \frac{5000}{3} = 1667 \text{ lb-in.}$$

From mechanics of materials, the section modulus, $I/c = M/s$, the quotient of the bending moment and unit stress. For the quotient function, Table 1,

$$\sigma_{I/c} = \sqrt{\left(\frac{\sigma_m}{s}\right)^2 + \left(\frac{M\sigma_s}{s^2}\right)^2}$$

$$= \sqrt{\left(\frac{1.667 \times 10^3}{1 \times 10^4}\right)^2 + \left(\frac{5 \times 10^4 \times 3.33 \times 10^2}{1 \times 10^8}\right)^2}$$

$$= 0.236 \text{ in.}^3$$

With respect to a section modulus of 5, the composite standard deviation of 0.236 is 4.72 per cent. It may be reasoned that a 10 per cent tolerance on the composite value is suitable; hence, $0.5/0.236 = 2.11\sigma$, which corresponds to 96.51 per cent of the values lying within the limits of $\pm 2.11\sigma$.

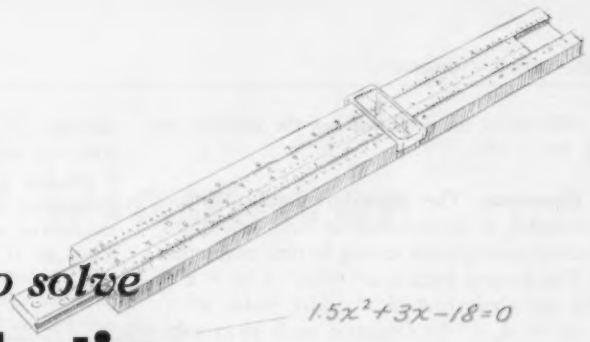
The 96.51 per cent is a composite value and compares with the 99.73 per cent assumed for each of the variables separately. If the 96.51 per cent is too little, the section modulus can be increased proportionately. For example, if a total range for the composite deviations is desired as 99.73 per cent, the corresponding values would need to be $\pm 3\sigma$ or $\pm 0.708$ in.$^3$

**Table 1—Resultant Deviations from Combinations**

| Function Relationship of Two or More Variables $s = f(u, v, \ldots)$ | Most Probable Value of Resultant Deviation $\sigma_s = f(\sigma_u, \sigma_v, \ldots)$ |
|---|---|
| $u + v$ | $\sqrt{\sigma_u^2 + \sigma_v^2}$ |
| $kuv$ | $k\sqrt{u^2\sigma_v^2 + v^2\sigma_u^2}$ |
| $k\dfrac{u}{v}$ | $k\sqrt{\left(\dfrac{\sigma_u}{v}\right)^2 + \left(\dfrac{u\sigma_v}{v^2}\right)^2}$ |
| $ku^n$ | $nku^{n-1}\sigma_u$ |
| $k \ln u$ | $\dfrac{k}{u}\sigma_u$ |


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# *How to solve*

# • Quadratics
# • Cubics
# • Quartics

## *by slide rule*

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QUADRATIC, cubic, and some quartic equations can be solved quickly, and directly with the slide rule. A simple rearrangement of the equation is usually necessary for the first step of the solution.

**Quadratic Equations:** Rewriting the general quadratic form, $ax^2 + bx + c = 0$ so the coefficient of the $x^2$ term is unity produces $x^2 + b_1 + c_1 = 0$, or $x + b_1 = -c_1/x$, where $b_1 = b/a$ and $c_1 = c/a$.

On the slide rule, $c_1/x$ is represented on the reciprocal ($CI$) scale, $x$, on the $D$ scale. The index of the $CI$ scale is set to the value of $c_1$ on the $D$ scale. As the cursor is moved, it indicates a range of pairs of numbers, one on each scale, whose product is $c_1$. Graphically, this represents moving along the $y = c_1/x$ curve, Fig. 1. To find the values of $x_1$ and $x_2$, two numbers are selected whose algebraic sum is equal to $b_1$. If $c_1$ is positive the numbers are additive; if negative, $c_1$ represents a difference. From the sign of the coefficient of $b_1$, signs for the solutions are known. If no slide-rule solution is found, there are no real solutions to the equation.

**Example:** Solve the equation $1.5x^2 + 3x - 18 = 0$. Making the coefficient of $x^2$ unity yields $x^2 + 2x - 12 = 0$. With the index of the $CI$ scale set at 12 on $D$, the cursor is moved to find two numbers, one on $CI$, the other on $D$, whose difference is 2 (since $c_1$ is negative and $b_1 = 2$). The values

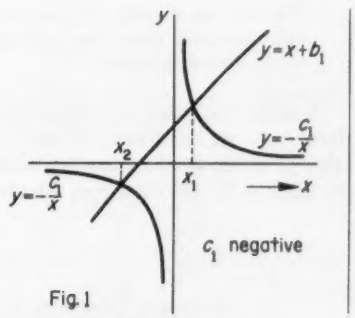



Fig. 1

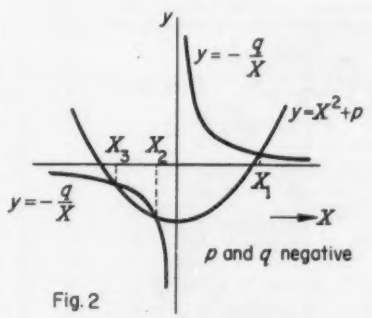



Fig. 2

2.605 and 4.605 satisfy the conditions and the solutions are $x = 2.605$ and $-4.605$.

**Cubic Equations:** The procedure for quadratics may be extended to the solution of cubic equations, where it offers even greater saving in time over other methods. The general form is $ax^3 + bx^2 + cx + d = 0$. Making the coefficient of $x^3$ unity yields $x^3 + b_1x^2 + c_1x + d_1 = 0$. Common with most solutions for cubic equations, the $x^2$ term is eliminated by changing the variable to X, where $X = x + b_1/3$. The result is a reduced cubic of the form $X^3 + pX + q = 0$, where $p = c_1 - b_1^2/3$; $q = d_1 - b_1c_1/3 + 2b_1^3/27$.

As in the case of the quadratic, the reduced cubic equation is rearranged and curves representing $y = X^2 + p$ and $y = -q/X$ can be plotted, Fig. 2. On the slide rule, the *CI* index is set at $q$ on the *D* scale and the value of $p$ is sought between the *A* scale ($X^2$) and the *CI* scale. Graphically, this represents moving along the reciprocal curve of $-q/X$ to find $X_1$ at the intersection with the parabola $X^2 + p$. One root of the equation is found on the *D* scale when the sum or difference (either may be tried) for $p$ has been found between the *A* and the *CI* scales.

After one root of the cubic is determined, the quadratic factor is solved as before. The numerical value for $c_1$ in the quadratic is on the *CI* scale corresponding to the first root found on *D*, and the value of $b_1$ for the quadratic is numerically equal to the first root but opposite in sign. Only two settings of the slide and cursor are required for complete solution of the reduced cubic.

**Example:** Solve the cubic $x^3 - 3x^2 - 22x + 60 = 0$. Eliminating the term in $x^2$ by letting $x = X + 1$ produces the reduced cubic $X^3 - 25X + 36 = 0$. The index of the *CI* is set at 36 on *D* and the cursor is moved to locate two numbers, one on *A*, the other on *CI*, whose sum or difference equals 25. Two possible numbers are 31.4 on *A* and 6.42 on *CI* giving one root, 5.605, on *D*. The equation becomes $(X^2 - 5.605X + 6.42)(X + 5.605)$, the signs being obvious from the signs of $p$ and q. Solution of the quadratic produces the other two solutions for X, which are 4.0 and 1.605. Therefore $x = 5.0$, 2.605, and $-4.605$.

If a root cannot be found for the sum of *A* and *CI* values, a difference should be sought, because the cubic may have one real and two imaginary solutions. The presence of imaginary solutions will be evident from the form of the remaining quadratic factor.

**Quartic Equations:** With slide rules having a *K* scale ($x^3$), quartics of the form $x^4 + b_1x + c_1 = 0$ may also be solved. Equations of this type can have a maximum of two real roots, both of which can be found separately. The technique for the reduced cubic equation is used, substituting the *K* for the *A* scale.

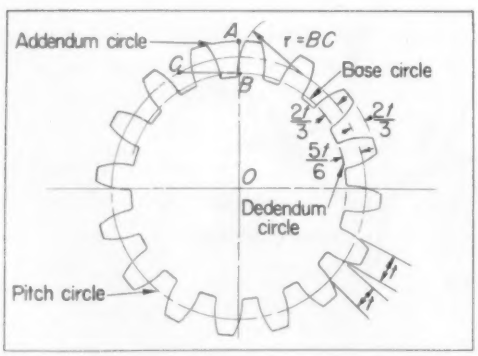
**Example:** Solve $x^4 + 2.4x - 16 = 0$. With index of *CI* at 16 on *D* solutions are found at cursor settings of $x^3$ = 9.86 and 6.28, giving the two values of $x$ as 1.843 and $-2.145$ on *D*. The corresponding numbers on the *CI* scale are 7.46 and 8.68 respectively.

# Tips and Techniques

## *Drawing Gear Teeth*

When it is necessary to draw a full gear profile, this approximate system can be very useful. The sequence is:

1. Draw the pitch circle and divide it into $2n$ equal arcs ($n$ = number of teeth). These pitch points are shown at distance $t$ apart on the figure.
2. Draw the addendum circle with radius $2t/3$ greater than the pitch radius. Draw the dedendum circle with radius $5t/6$ less than the pitch radius. Draw a base circle with radius $2t/3$ less than the pitch radius.
3. Draw any radial line *OA*, crossing the base circle at *B*. Draw a perpendicular to *OA* through *B*, intersecting the pitch circle at *C*.
4. With radius *BC* draw the arcs of the tooth flanks through each pitch point from centers on the pitch circle.
5. Complete the drawing with segments of the addendum and dedendum circles and radii from the tooth arcs to the dedendum circle.




A slight reduction of radius *BC* will allow tooth-flank arcs to be drawn in pairs. This reduction is also necessary to avoid overlay when gears are shown in mesh.—W. H. SHEPPARD, *Montreal, Quebec.*

*Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor,* MACHINE DESIGN, *Penton Bldg., Cleveland 13, O.*

# Pulley Diameter *vs.* Wire Size

**. . . a nomographic method for finding the minimum pulley diameter that will prevent deformation of a given wire size**

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DETERMINING the minimum-size pulley over which wire or strip material can be wrapped without deformation is a frequent problem in the design of wire or strip-processing equipment.

Mathematically, minimum pulley size may be derived according to the classic beam theory, as follows:

$$e = \frac{r}{R + r} = \frac{d}{D + d} = \frac{S}{E}$$

Symbols used in the equation, and shown in Fig. 1, are defined in the Nomenclature.

By simple algebraic manipulation, the equation can be solved for $R$ or $D$:

$$R = r\left(\frac{E}{S} - 1\right)$$

$$D = d\left(\frac{E}{S} - 1\right)$$

Because $E/S$ is very much greater than 1, the equation may be simplified to $R = r\ (E/S)$
or

$$D = d\frac{E}{S}$$

If the material is in strip form, the equation becomes

$$D = t\frac{E}{S}$$

The nomograph in Fig. 2 provides a rapid solu-

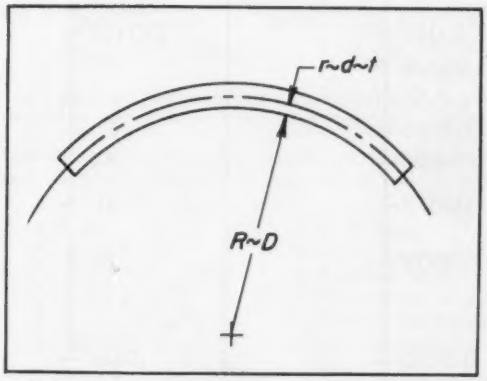



**Fig. 1—For small wire sizes, relative to pulley diameter, several of the basic dimensions may be assumed equal to one another without great error in the calculation of minimum pulley diameter.**

**Nomenclature**

| | |
|---|---|
| $D$ | = Diameter of pulley, in. |
| $d$ | = Diameter of wire, in. |
| $E$ | = Young's modulus, psi |
| $e$ | = Unit elongation, in. per in. |
| $R$ | = Radius of pulley, in. |
| $r$ | = Radius of wire, in. |
| $S$ | = Yield strength, psi |
| $t$ | = Thickness of strip, in. |

tion to these equations for an approximate minimum pulley size.

**Example:** Assume that a wire having a diameter of 0.005 in., a Young's modulus of 30,000,000 psi, and a yield strength of 60,000 psi is to be wrapped around a pulley. Find minimum pulley size that will prevent "set" of the wire.

Locate points for 0.005 in. on the wire-diameter scale and 30,000,000 on the Young's modulus scale, and connect the two points with a line. Draw a line from the point of intersection with the reference line through the point for 60,000 on the yield-strength scale. This final line intersects the pulley-diameter scale, and gives the solution, 2.5 in.

**Wire under Tension:** If the wire is under tension, such added stress may have to be considered. A simple way to account for tension is to subtract the tensile load (psi) from the yield strength before solving the equation for minimum-pulley diameter or using the nomograph, Fig. 2.

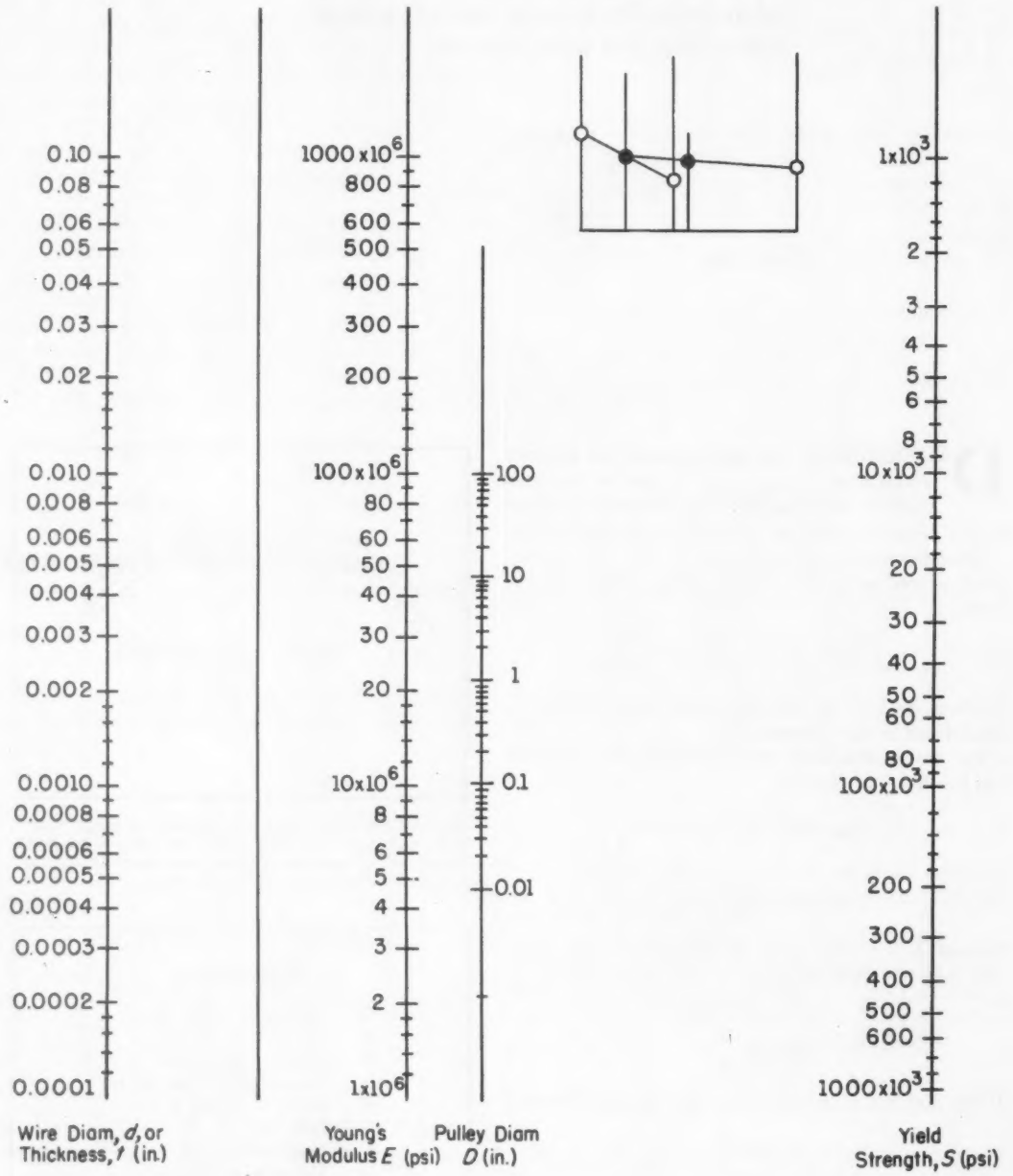


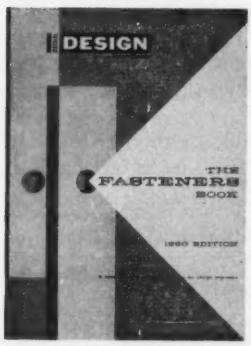

Fig. 2—Nomograph gives minimum pulley diameter $D=d\ (E/S)=t\ (E/S)$.

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MACHINE DESIGN

## Application factors for

# Small Diesel Engines

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AN OBVIOUS trend in Europe is the application of the diesel engine to smaller and smaller commercial vehicles. There is now considerable evidence that the same trend is starting in North America. Factors which are likely to affect the adoption of small diesel engines (below 400 cu in.) are discussed here.

In cases of direct substitution of diesel for gasoline engines, the most important single factor is first cost. Until diesel engine sales increase appreciably, transmission characteristics and installation requirements will be dictated by the gasoline engine. Unfortunately, the essential differences between the diesel and gasoline engines make these requirements more difficult to meet as the engine and vehicle size is reduced.

**Engine Speed and Combustion Systems:** A major factor in determining the suitability of a diesel engine of a given power is the engine speed at which the required power is obtained. In the past, diesel engines have suffered from engine speeds too low to give adequate operational flexibility. However, maximum engine speeds now possible must be weighed against the requirement for minimum fuel consumption.

The limitation on diesel engine speed is imposed as much by the combustion system as by mechanical design. Antechamber or indirect-injection combustion systems which have been developed are capable of smoke-free operation at high bmep, above the speeds at which gasoline engines are rated. But these indirect systems give specific fuel consumptions 10 per cent or more greater than open-chamber or direct-injection systems. The direct systems, however, at their present stage of development, have a top speed limitation around 3000 rpm in cylinder bores of 3.5 to 5.0 in. Therefore, it is necessary to consider whether it is better to have an engine which will replace the gasoline equivalent without any alteration to the transmission ratios, or whether the cost of a change in axle ratio to allow the use of a lower top engine speed is justified by lower fuel costs.

These factors are illustrated in Table 1, Fig. 1, and Fig. 2. The close similarity between the two torque curves (bmep) in Fig. 1 indicates that essentially the same vehicle performance can be obtained provided the transmission ratios are adjusted to compensate for the different maximum engine speeds. According to Fig. 2, the direct-injection engine shows a fuel savings which justifies the change in axle ratio.

Better cold starting characteristics of the direct-injection engine is another reason for using a direct-injection system. This advantage, and others, apply to medium-sized truck, and similar applications. Engines of capacity less than about 200 cu in. must operate at speeds above the present practical limit of 3000 rpm for direct-injection combustion systems. The achievement of a satisfactory direct-injection system is also increasingly difficult as

**Table 1—Alternate Diesel Engines**

| | Engine A | Engine B |
|---|---|---|
| Number of cylinders .. | 6 | 6 |
| Max Speed (rpm) ..... | 2800 | 3500 |
| Max Power (bhp) ..... | 112 | 119 |
| Combustion System.... | Direct | Indirect |
| Cylinder Capacity (cu in.) ..... | 354 | 283 |
| Bore (in.) ..... | 3.875 | 3.875 |
| Stroke (in.) ..... | 5.00 | 4.00 |
| Max Torque (lb ft).... | 260 | 210 |
| Max Torque Speed (rpm) | 1450 | 1850 |



# IPC has a new baby!

I.P.C.'s extensive research in the area of fluorocarbon plastics has given birth to *a whole new series of custom seals, ball seats, diaphragms, V, cup and flange packings.*

Designated as the F-C series, these thoroughly tested components are literally a blend of I.P.C. synthetic rubbers and fluorocarbon plastics. This unique combination produces seals and packings with *lower friction, less torque, better corrosion resistance and reduced shaft wear.*

You can handle increased pressures . . . higher shaft speeds *and* most high temperature applications with F-C seals and packings. Special molding machinery and techniques have been developed by I.P.C. to produce this combination. Synthetic rubber, fluorocarbon plastics and steel cases are brought together in one operation to provide the last word in high quality case seals.



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OIL SEALS
PACKINGS
PRECISION MOLDING
*Custom designed for your application.*

*There's good reason to look at the newest member of I.P.C.'s* custom family *in terms of your sealing problems. Do it soon; Won't you?*

## INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

P4

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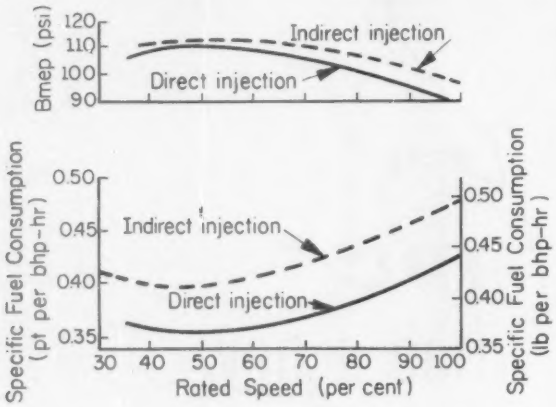



Fig. 1—Fuel consumption at rated speeds for alternate injection systems. Engine data are given in Table 1.

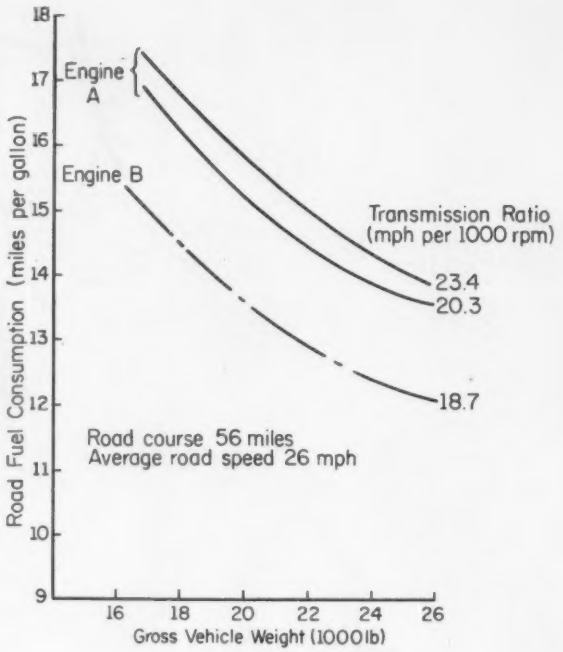



Fig. 2—Fuel consumption for alternate engines at rated vehicle loads. Engine data are given in Table 1.

the cylinder bore is reduced.

Indirect combustion systems have now been developed which impose no practical limit on engine speed. Operation of a production engine up to 5000 rpm with good efficiency is quite possible. There is, in fact, no need for even the smallest diesel engines to be rated above 4000 rpm. Increased engine cost and reduced life which the higher speed would entail cannot be justified.

**Stroke Bore Ratio:** The strong trend toward short-stroke gasoline engines has greatly influenced the design of engine compartments into which diesel engines must fit. Since V-8 gasoline engines are short and compact, they create increased problems for the conventional diesel.

One obvious answer is the development of V-8 diesels. This is not a good answer, however, because the V-8 engine is more expensive than the inline six. Therefore, the diesel engine must have maximum stroke-bore ratio to keep engine length to a minimum. Increased stroke-bore ratio gives improved thermal conditions, a more rigid cylinder block and head, and more advantageous air-swirl conditions in the cylinder. Engine-torque output at low speeds is also improved. Optimum stroke-bore ratio is 1.3.

**Size and Weight:** The diesel is now becoming comparable in size with the gasoline engine. The principal measures taken to produce this condition have been the increase in engine speed and, to a lesser extent, higher mean effective pressures. A better understanding of the internal engine stresses and improved materials have also contributed.

**Installation:** It is rarely satisfactory to mount a diesel on the same engine mountings as used for a gasoline engine. Softer mounts are required and provision must be made for greater engine movement at low speeds. In respect to cooling, the diesel has a considerable advantage over the gasoline engine in lower heat rejection. But the gasoline engine has a considerable tolerance for overheating which the diesel engine has not. When difficulties do arise in a diesel, they are generally due to inadequate clearance around the fan, and restrictions in the release of the cooling air from the engine compartment.

Air cleaners, fuel systems, and similar features demand treatment which differs in some degree from gasoline practice. This presents no difficulty if past experience with diesel engines is followed.

*SAE Paper No. 215A, "Diesel Development in Medium and Small Commercial Applications," presented at the SAE West Coast Meeting, San Francisco, August, 1960, 8 pp.*

# New Welding Processes

JOHN J. CHYLE, Director of Welding Research, A. O. Smith Corp.

The new metals developed for the space and atomic age have characteristics and properties which require new methods of processing and new welding procedures. Pressure welding, fusion welding, and brazing are the broad groups of welding processes. Selection is governed by type of metal to be joined, design of weldment, cost, and engineering and service requirements.

## Pressure Welding

Pressure welding is a term applied to a group of related welding processes in which the use of force is of primary importance in obtaining the coalescence of metal, with or without the application of heat.

**Ultrasonic Welding:** In this process, the energy to effect a weld is derived from the use of special equipment, using elastic vibratory energy in the joining of metals. Both spot

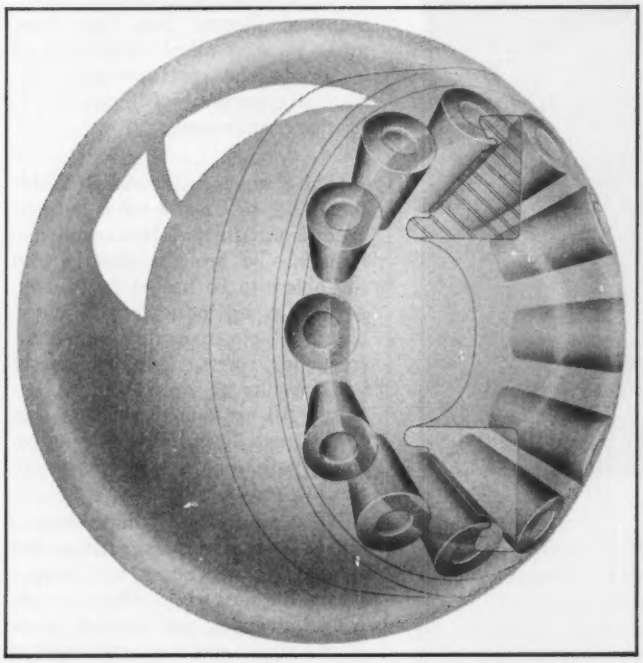
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

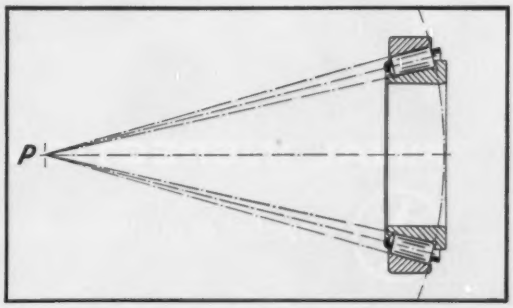
One in a series of technical reports by Bower

**BEARING BRIEFINGS**

# SPHERICITY—ESSENTIAL TO MAXIMUM BEARING PERFORMANCE



*When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.*




True rolling of tapered bearing elements depends upon maintaining a true spherical radius during manufacture.

**For a tapered roller bearing to achieve maximum performance, i.e., maximum life and capacity under load, it must have true sphericity — a condition of bearing geometry which permits true rolling of the tapered rollers in the raceway.**

True rolling in tapered bearing elements is the result of maintaining a critical geometric relationship between the raceways and the contact surfaces of each roller. True rolling is essential to maximum performance. Without it, premature bearing failure is certain.

As engineers know, a tapered roller will describe a true circle when rolled on a plane surface. *It will always roll in this one path precisely, without sliding or skewing.* But to put true rolling to work in a bearing which can carry both heavy thrust and radial loads, it is essential that the rollers *and* the raceway have a true spherical radius, or sphericity. The drawing illustrates this condition.

If each roller in the bearing were to be extended in length, while retaining its taper, it would form a cone, terminating at point "P". All cones generated from all rollers would meet at point "P", which is also the center of the hypothetical sphere shown. The surface of the sphere would *touch all points on each roller's head!*

In effect, then, each roller's taper determines the radius of a hypothetical sphere whose surface, in turn, determines the correct contour for each roller head. Only when these conditions are satisfied in design, and when they are rigidly held during manufacture, will true rolling take place. In the manufacture of each Bower tapered roller bearing, sphericity is held within extremely narrow limits by means of special Bower-designed precision grinders. The consistent accuracy possible with these machines is one major reason why Bower roller bearings provide maximum performance under all speeds and loads up to the bearing's maximum rating.

**BOWER ROLLER BEARINGS**

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN



Circle 491 on Page 19

and seam welding of metal sheets can be accomplished.

Metals difficult to weld by conventional methods can often be joined by means of this process: Stainless steel, molybdenum, zirconium and its alloys, Inconel, tantalum, and titanium. Ultrasonic welding is also used for the joining not only of similar but also dissimilar metals, such as copper to aluminum.

At the present time the limitations of this process are for the joining of light-gage or thin sheet materials. Foil thicknesses can be joined readily, but there is some limitation as the gage or thickness of the sheets is increased. Recent tests have been made in sheet-metal thicknesses of 0.090 in., and spot strengths substantially exceed the Military Specification requirements.

**High-Frequency Resistance Welding:** This process depends on the condition that high-frequency current can be brought directly into the object to be heated by contact, as well as by induction. The use of contact electrodes to bring high-frequency current into a piece of work results in several peculiar effects. All are due to the fact that the current flows in the low-inductance path, but not necessarily in the low-resistance path.

This process is applicable to a wide variety of metals, such as aluminum, brass, copper and copper alloys, stainless steels, silicon bronze, Monel, Inconel, and Incoloy. Some of the highly reactive metals such as titanium, titanium alloys, and zirconium alloys have been successfully welded with this process, using inert gas for shielding.

One of the advantages of this process is the high speed that can be obtained. Speeds up to 1000 fpm are possible in light-gage materials of 0.012 in. thickness. This process is not limited to tubing, but can be applied to other shapes such as strips, T-sections, and so on. Spiral strips of metal can be welded to the surface of the tubes.

A significant advantage of this process is the narrow heat-affected zone obtained, due to the relatively narrow band of heating. This narrow or localized heating also accounts for the greater efficiency of




In the production of exacting rubber products, such as "O" Rings, custom-molded products, or rubber to metal bonded products, final inspection plays a dual role... it double-checks on all previous production processes, and makes sure that the finished product meets all quality requirements.

Standard and PARCO designed inspection tools combined with the efficiency of specifically trained inspectors assures all products are perfect for delivery and ultimate application.

This is why, at PARCO, final inspection is a symbol of quality assurance.

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**PLASTIC AND RUBBER PRODUCTS COMPANY**
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the electric power used. The narrow weld zone may result in high tensile strengths and ductility.

**Foil-Seam Welding:** This is a new welding process that has found application where high-speed welding and freedom from distortion are important. It is a resistance welding process for making butt-type joints in flat strips or sheets, using a foil on either the top or bottom, or both, surfaces over the butt joint. The thin foil strips which are from 5/32 to 3/16 in. wide and 0.007 to 0.010 in. thick are used directly over the square abutting edges.

An advantage of this process is the high speed of welding, with speeds from 3 to 24 fpm on 0.087-in. stock. Another advantage is the freedom from distortion, with the joints being flat and requiring little, if any, final dressing of the weld metal. The surface of the weld can be painted or glass-lined without subsequent grinding or processing operations.

**Magnetic - Force Welding:** The basic principle of magnetic force welding is the synchronization of the force or pressure by means of coupling this force with magnetic force, created by the welding current. This new principle of force application allows extremely accurate synchronization of the electrode force and the welding current.

In most of the applications for this type of weld, the welding time is of short duration, varying from ½ cycle to a few cycles.

The advantage of the magnetic-force welding process is that it can be used for the welding of high-conductivity metals to each other, and also to carbon steels.

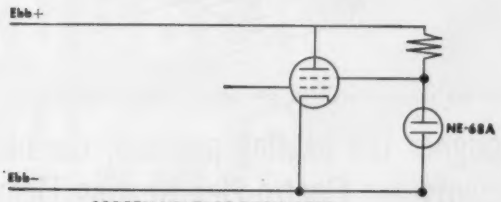
**Percussion Welding:** This is a newly developed resistance-welding process in which the weld is made in an exceedingly short period of time over the entire area of the metals to be joined.

The weld can be produced either by a rapid discharge of electrical energy from a stored-energy type of power source, or by the rapid dissipation of current with a standard 60-cycle alternating-current source. The principle of operation in this




1½ Times
Actual Size

# SPECIAL G-E GLOW LAMP (NE-68A) HOLDS VOLTAGE VARIATIONS TO LESS THAN 3 V




SCREEN VOLTAGE REGULATOR

Here at last is a glow lamp with true voltage regulation specifications. Within a range of 52 to 65 volts, each individual General Electric NE-68A will not vary more than three volts even though current through the lamp fluctuates between .1 and .3 milliamps. Minimum maintaining voltage of all NE-68A's at .1 milliamps is 52 volts; maximum voltage at .3 milliamps is 65 volts.

The G-E NE-68A is a pre-aged glow lamp with plated leads to make soldering easier. It contains a mild radioactive additive for reduced dark effect. Special treatment with the G-E Dri-film process insures high leakage resistance under humid conditions.

**DIRECT CURRENT CHARACTERISTICS**

| | |
|---|---|
| Breakdown Voltage (in light) | 60-90 volts d-c |
| Breakdown Voltage (in dark) | 110 volts d-c maximum |
| Maintaining Volts (.1 to .3 m.a. range) | 52-65 volts d-c |
| Extinguishing Volts (in series with .25 megohm or more) | >50 volts d-c |
| Design Current | 0.1 to 0.3 m.a. |
| Leakage Resistance at 75% RH and 80°F | 100 megohms or more |
| Life (at .3 m.a. d-c for an average change of 5 volts in maintaining voltage) | 2000 hours |

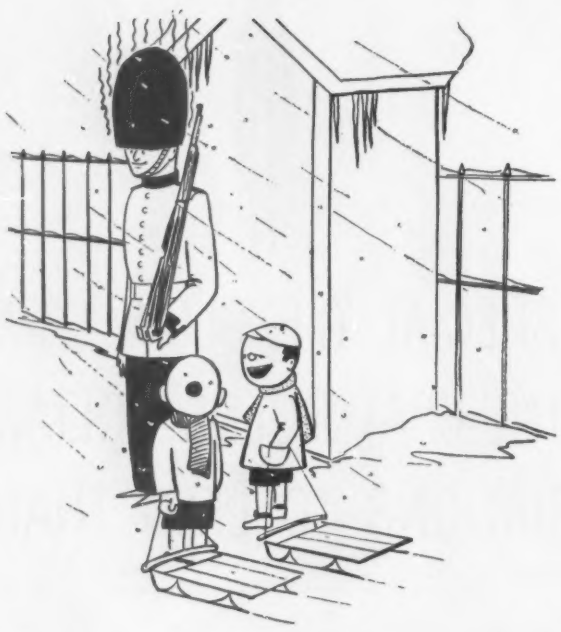
There is a General Electric Glow Lamp to fit your circuit requirements. For the latest information on Glow Lamps as Circuit Control Components and Indicators, write for 4-page Bulletin #3-0193. General Electric Co., Miniature Lamp Dept. M-034, Nela Park, Cleveland 12, Ohio.

*Progress Is Our Most Important Product*

GENERAL ELECTRIC




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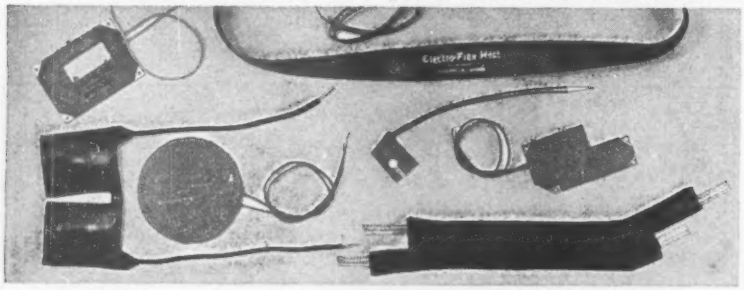


*"Blimy, why should 'e get cold? He's got a 'eating h'element in 'is bonnet."*

## The tougher the heating problem, the better the opportunity for Electro-Flex Heating Elements

For every ridiculous application you can think of there are thousands of practical ones where Electro-Flex heating elements can lick a cold problem. Opportunities are endless. Electronic and mechanical equipment can be made operable, resin cements and plastic laminates can be heat cured, aircraft surfaces can be de-iced, drains defrosted, instruments protected—just to name a few examples.

Electro-Flex has the reputation for solving difficult heating problems better and faster. Engineering is in the hands of experienced heating experts. So, what is your heating problem? Send us the specifications of the application or contact our engineering department for further information.



Any size, large, small or very thin.
Lightweight, tough or flexible.
High voltage tested.
Resist corrosion—Immersible.
Insulated with silicone rubber, neoprene, Kel-F Resin, Polyethylene, etc.
Standard units available.
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process is that the part to be welded has a small pinpoint type of formed or coined projection which is instantaneously vaporized upon contact during the downward movement of the electrode.

One of the advantages of this process is the welding of large contact areas with the smaller capacity machines, and the high quality of weld that is produced.

This welding process may have wide applications in the fabrication of ferrous as well as nonferrous metals, particularly for attaching small parts to very thin sections.

**Friction Welding:** This pressure-welding process, described in Russian literature, can be considered an addition to the list of new processes. The principle of the operation is based on heat produced by friction of rapidly moving parts.

Limitation of this process at the present time is to parts that are cylindrical in shape and can be rotated.

Some inherent advantages of the friction-welding process may be found in low cost of power requirements and high speed of operation. It has interesting possibilities for special applications to production welding of simple sections, because of lower initial capital investment costs.

**Thermo-Pressure Welding:** This process can be considered in the field of solid-phase welding. The parts to be welded are under continuous pressure and the metal is heated until complete or partial plastic flow is obtained. Pressure may range from 5000 to 10,000 psi, and the temperature of heating may range from 200 to 300 C.

This process has found applications particularly in the joining of semiconductors to metals like germanium and silicon. It may solve many of the problems related to making contacts to small areas without using chemical fluxes and melting in the fabrication of transistors and other semiconductor devices.

**Diffusion-Bond Welding:** This process may be defined as pressure welding in which the metals to be joined are heated to temperatures below their solidus, and are held



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under pressure for some length of time. No liquid phase is formed and the bonding occurs by movement of atoms or intermetallic compounds across the interface on the surfaces, where intimate contact occurs.

At the present time diffusion-bond welding has been investigated for applications to only a few metal combinations, such as the joining of beryllium-copper alloys to Monel and other metals. However, this process appears to have promise for joining of many dissimilar types of metals and alloys which cannot be joined together by fusion welding.

### Fusion Welding Processes

Fusion welding is a term applied to a group of related welding processes in which the use of heat is of primary importance in obtaining the coalescence of metal.

**Electroslag Welding:** One of the most recent developments in fusion welding is electroslag welding, first reported in Russia. Fusion of the electrode wire and the parent metal takes place in and under a molten-slag bath covering the metal bath from which the weld is formed. The electrode wire or wires are immersed in the liquid slag. This process is used primarily for welding of heavy sections, and can be used for welding plates ranging in thickness from 2 to 12 in. or more.

Electroslag welding can be most readily adapted for welding vertical butt joints in heavy weldments, but also can be used for welding of girth seams in heavy-wall cylinders, as well as building up large surfaces with weld deposit.

One of the advantages of this process is the high metal deposition rate, which may be as high as 45 lb of weld metal per hr per single wire. Another advantage is the higher thermal efficiency that is obtained with this resistance-heating process, when compared to the true arc-welding efficiency of the submerged-arc welding process.

One limitation of this process is the large heat-affected zone area adjoining the weld, and the coarse columnar structure of the weld-metal deposit. Recommendations have been made to heat-treat the weld-




**Flexible temperature range**
**-100° F TO 500° F**

COHRlastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRlastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening.

COHRlastic R-10470 meets: *AMS 3195; AMS 3196; Boeing BMS 1-23; Martin–MMS C451 and MB 6103; Scintilla 9-3143; Bendix ES-0709; Douglas DMS 1597; Lockheed LAC 1-924; Minneapolis Honeywell 6384-3 and Sperry Gyroscope P.691.764 Type HTM.*

*AVAILABLE FROM STOCK:* in 12″ x 12″ sheets and 24″ x 24″ sheets — 1/16″ through ½″. Special thicknesses and sheet sizes up to 30″ x 30″ and 24″ x 48″ can be made to order. COHRlastic R-10470 is sold nationally through distributors.

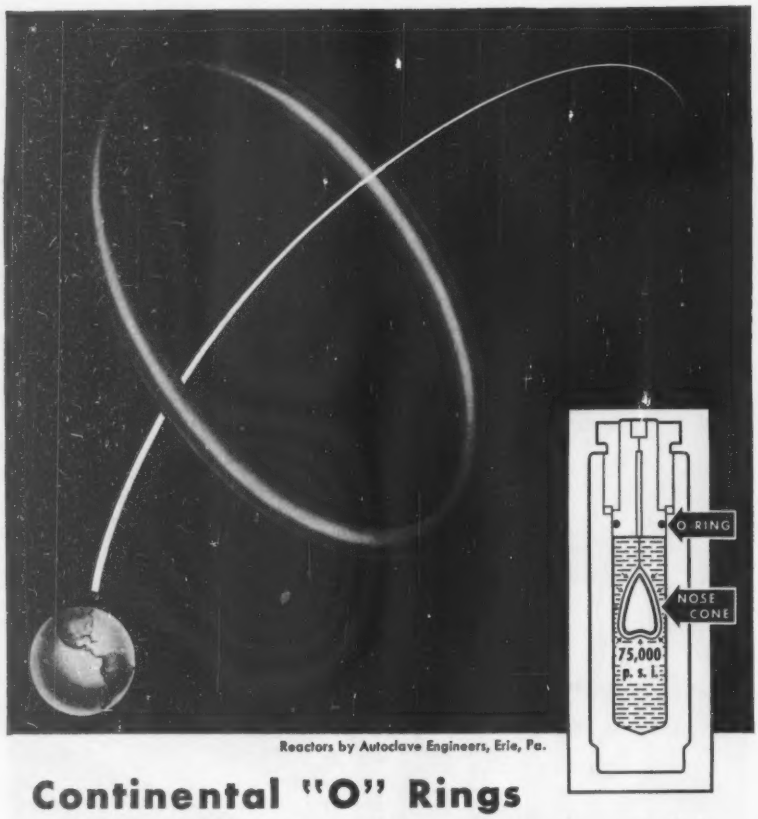
*CHR PRODUCTS INCLUDE:* Airframes and engine seals, firewall seals, and coated fabrics; Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber; silicone cements; conductive gasketing; and Temp-R-Tapes — pressure-sensitive, thermal curing Teflon* Fiberglas and silicone rubber tapes.

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Reactors by Autoclave Engineers, Erie, Pa.

## Continental "O" Rings Help Put Satellites in Orbit

Almost as dramatic as the thrust of a satellite into outer space is the technique used to fabricate the nose cone of the missile. These nose cones, made either of powdered metals or refractory materials, are being compacted in 12" I.D. pressure vessels under hydrostatic pressure of 75,000 P.S.I. *Imagine the problem involved in sealing a vessel against such terrific pressure!*

Yet *THAT* is the problem solved by this Continental "O" Ring. Obviously an ordinary "O" Ring would not do. The job called for a special compound with molecular formation so precise that separation or micro-leakage just could not occur. Continental developed the compound that meets this rigid test. What's more, the elasticity of the rubber refuses permanent set and thus permits re-use of the ring.

This unusual rubber problem typifies the complete engineering service available to you here at Continental. Whether you need molded or extruded rubber parts, consult with us *while your new products are still on the board.* Let us suggest how you might save both tooling and material costs—and get a better product for the job.

**Hydrostatic Pressing (see diagram).**

*A technique for producing uniform compaction and grain structure to obtain super hardness and impact resistance in critical components. A steel forming-mandrel is coated with a refractory material, placed in a rubber bag and suspended in pressure vessel. Pressure is applied until required density is attained.*

**Engineering catalog.**

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

*Another achievement in* **RUBBER**
*engineered by* **CONTINENTAL**

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ments by a normalizing type of post-heat-treatment, to refine the grain structure. On very large weldments, this would be a costly heat-treating operation, and problems of distortion would have to be considered.

**Electron-Beam Welding:** This is a relatively new welding process. The principle of its operation is based on the impingement of electrons on the work piece in high vacuum. The electrons are emitted from a tungsten-wire filament, and are given a high degree of acceleration and velocity by a high-voltage potential between the cathode and anode, the electrons moving from the cathode to the anode. The workpiece is the anode.

One advantage is the absence of an electrode or an arc in close proximity to the welding area. This eliminates a source of contamination since the heating is being done by a beam of electrons originating at some distance from the weld. It is also possible to build into electron-beam welders an optical system for direct viewing, or an indirect optical system that can be focused to the work area.

Another significant advantage of this process is that the most reactive and refractory metals can be welded without contamination.

One of the outstanding characteristics of the process is the deep penetration. Tests so far have indicated that it is possible to obtain a depth to fusion width ratio of 2 to 1, which implies a high temperature gradient.

The following metals have been satisfactorily welded: Tungsten, molybdenum, beryllium, tantalum, zirconium, and hafnium. The process can also be applied to some of the more common alloys such as stainless steel and carbon steels.

One of the disadvantages of this process, when operating at the very high voltages, is the emission of penetrating short-wave radiation (x-rays), which requires protection or shielding for personnel.

**Arc Plasma:** One of the newer achievements in recent years has been the development of arc-plasma type of heating, which produces extremely high temperatures ranging from 10,000 to 30,000 F. The basic

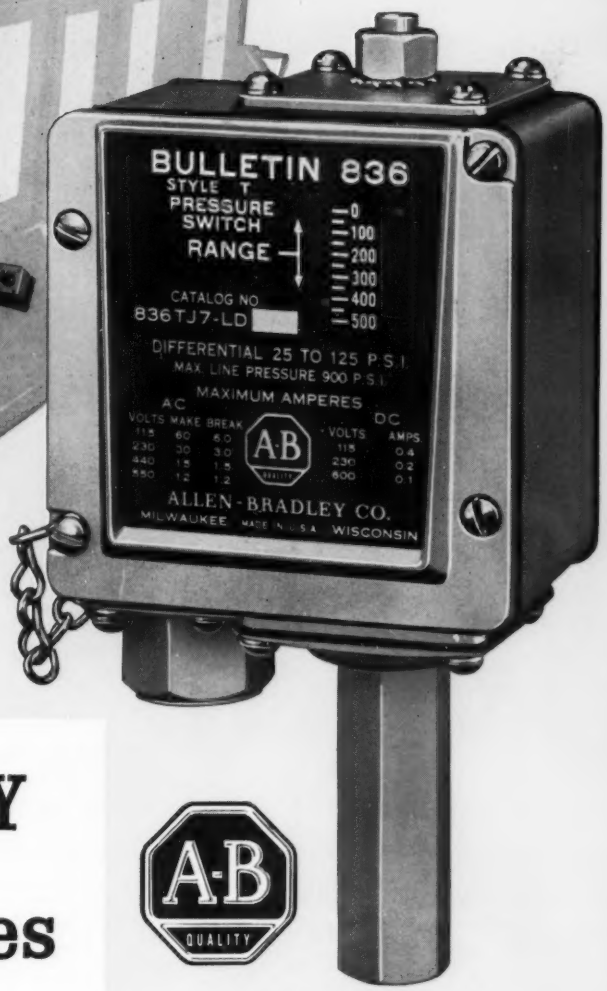


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Ten-station transfer machine in use at major auto plant. This view shows 9 of the 45 A-B Bulletin 836 pressure switches and 2 special Allen-Bradley control stations on the machine.




# ALLEN-BRADLEY

## OILTIGHT

# Pressure Switches

*provide consistent accuracy and maximum reliability*

Bulletin 836 Style T
Oiltight Pressure Switch

These rugged Allen-Bradley Bulletin 836 Style T oiltight pressure switches are specifically designed to take the punishment of hard, day-in and day-out industrial use. The die-cast aluminum housing is completely sealed. Oil cannot get in and foul the contacts—even when it flows over the enclosure in a continuous stream. The precision switch mechanism insures extreme accuracy of repeatability. An extremely important feature lies in the "snap action" of this switch—it maintains its normal contact pressure up to the instant of switchover—regardless of how slowly the trip point is approached. Contact chatter—which means unreliable operation—is impossible, and contact life is greatly increased. The contact block has two isolated circuits with one N.O. and one N.C. set of contacts.

Both the operating pressure and the differential are adjustable. The pressure is externally adjustable with the setting shown on a calibrated scale, and a trip indicator shows the operating point. These A-B *quality* controls are made for operating at pressures up to 5000 psi. Write for full details.




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**QUALITY MOTOR CONTROL**

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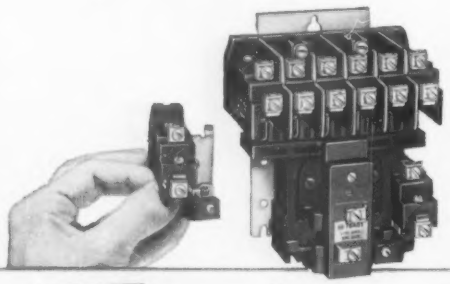
# 60 Second Contact Convertibility

## ALLEN-BRADLEY CONTROL RELAYS

can thus easily be changed
from N.O. to N.C. (or vice versa)

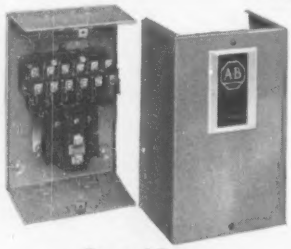
Why not give yourself a real surprise! We refer to the ease with which you can convert the contacts of these Allen-Bradley Bulletin 700 Type BR control relays. Using only a screwdriver, contacts can be changed from normally open to normally closed (or vice versa) in seconds—without removing the relay from its mounting—or its wiring. This "on-the-spot" convertibility certainly suggests an appreciable moneysaving reduction in your relay inventories.

Extensive tests have proven conclusively that the Bulletin 700 Type BR relays are good for many—and we mean *many*—millions of trouble free operations. A "built-in" permanent air gap completely eliminates all possibility of magnetic sticking. Naturally, the double-break, silver contacts never need attention. Also, the molded coil is your assurance that even the most severe atmospheric conditions cannot cause trouble. Please write for full details on these relays today!



**BUT HEAR THIS!**

In the event that when "on-the-job" it is discovered that something was either overlooked or added, the standard Bulletin 700 Type BR—either 2, 4, or 6 pole relay—can easily have added to its base, out in the field, either one or two switching poles. It is done as easily as "falling off a log."



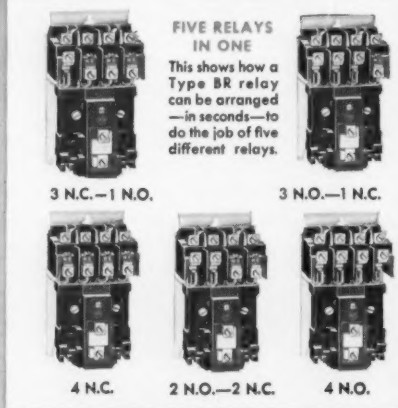
General-Purpose
NEMA 1



Explosion-proof
NEMA 7



Waterproof
NEMA 4




15-60-R

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principle consists of passing a gas through a chamber in which an arc is maintained. The flow of electrons from the cathode to the anode ionizes the gas, and the resultant bombardment causes the gas to be heated to extremely high temperatures. The passages in the arc torch are constricted so that the walls of the torch, which are water-cooled, do not become hot. The ionized gases are forced through a nozzle opening, so that the heated gases have the appearance of a flame emanating from the end of the chamber.

The present application of the plasma torch is for spraying of metals and refractory materials. At the present time the arc plasma has been developed primarily as a source of heat, and while some equipment has been developed for metal and ceramic-material deposition, the process has a vast potential for future applications in fusion welding of metals.

### Brazing

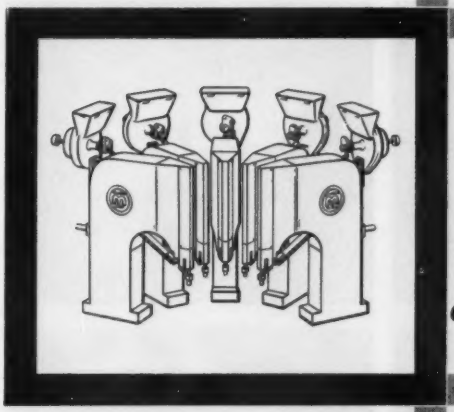
Brazing is a term applied to a group of welding processes in which coalescence is produced by heating to suitable temperatures above 800 F. and using a filler metal with a melting point below that of the base metals. The filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction. Flux may or may not be necessary, depending upon the method of heating and metals to be joined.

One outstanding brazing achievement is the development of what is commonly called the "sandwich-type construction." The basic element is a core of honeycomb or corrugated section which is made of metal foil and is placed between the outer skins, with a suitable brazing alloy interposed between the core and the outer flat surfaces.

The materials can be any of the various types of stainless steels, titanium alloys, and certain high-temperature alloys. The brazing operation can be performed in a number of ways, such as furnace brazing with partial vacuum or an inert-gas atmosphere to prevent oxidation, and with graphite blocks to maintain the proper dimensional stability and flatness.


NEW "BUILDING BLOCKS" ... for automatic riveting



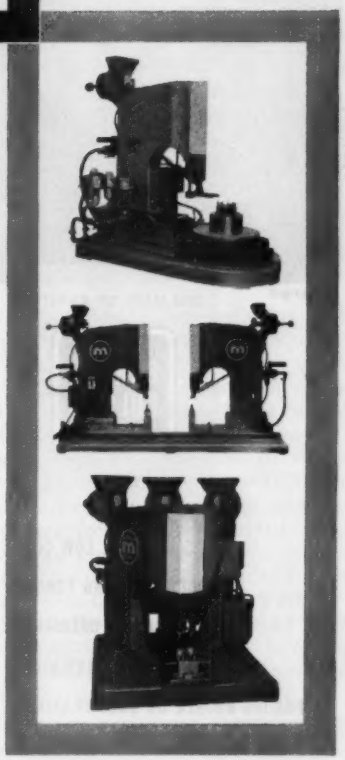



*Milford's Models 56 and 57 offer unlimited flexibility in automatic assembly*

The narrow wedge shape of Milford's new air-actuated riveters permits unusually close riveting. Both models can be combined with sliding-fixtures, indexing tables or similar attachments to give greatest flexibility of assembly. Air-operated toggle action assures fast and safe action. Model 56 handles tubular rivets from 1/8" diameter x 3/8" length; Model 57 from 3/16" diameter x 3/4" length.

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For more new ideas, tips and technical data on tubular rivets and rivet-setting machines, ask your Milford Representative for a look at Milford's new MANUAL OF MODERN RIVETING PRACTICE.



THE MILFORD RIVET

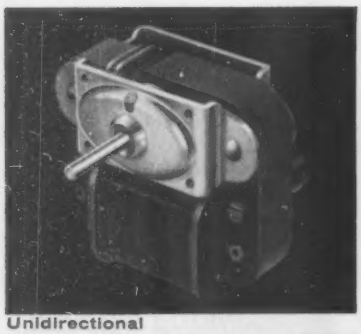
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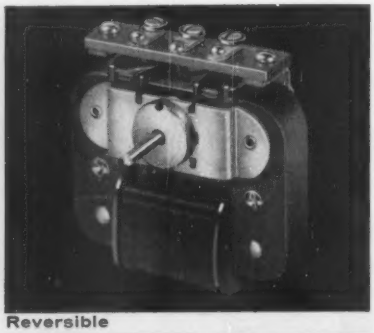

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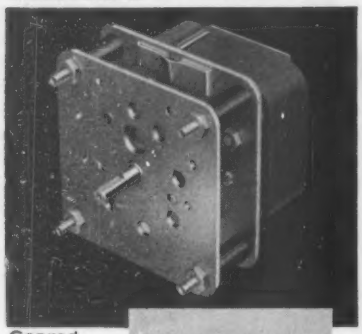
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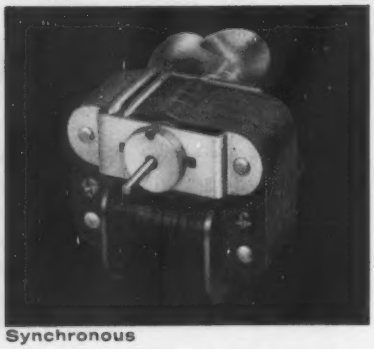
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The advantage of the brazing process, as applied to honeycomb construction, is that it makes possible the welding or joining of extremely light sections in large areas, for high rigidity and strength.

Another advantage is that large areas on panels can be brazed in one operation. In some of the alloys that have been selected, the heat-treatment encountered in brazing can be slightly modified so as to improve or increase the mechanical properties of the alloy. For example, the brazing temperature can be considered as a solution heat-treatment which is followed by a subnormal cooling and a tempering or precipitation treatment.

The development of many of the new arc-welding processes has resulted in high speeds ranging up to 400 ipm, and the guiding of the arc is becoming an increasingly difficult problem. Several new principles for automatic guidance have been developed for high-speed welding.

Further developments on new welding processes, new welding power sources, and new concepts in welding are to be expected. The use of explosives for explosive welding has already been investigated and promising results obtained. Rocket-propellant solid fuel has also been investigated, and preliminary trial has shown that it is possible to use the new heat source for fusion welding. As developments occur in other fields, similar strides will be made in welding.

*ASME Paper No. 60-MD-3, "New Welding Processes," presented at the Design Engineering Conference, New York, May,* 1960, 16 *pp.*

## materials

### Stress Concentration Effect On Strength of Titanium and Steel in Temperature Ranges

*George Sachs, associate director, and John G. Sessler, senior project engineer, Syracuse University Research Institute*

Effect of stress concentrations on the nominal tensile strength of a number of ultra-high-strength steels and heat-treated titanium alloys in sheet form and at temperatures from −320 F to 800 F.

The major factor influencing the degree of notch sensitivity of titanium and steel alloys is the actual tensile strength of the material. Below a certain minimum strength, neither steel nor titanium alloys exhibit sensitivity to stress concentrations at room temperature. Above the minimum strength level, notch sensitivity develops and it becomes more severe with increasing tensile strength.

As $K_t$, stress concentration factor, is increased from a value of 1 (no notch), slight notch-strengthening occurs in all conventional alloys except for some steels at very low temperatures.

Further increase in $K_t$ results in a decrease in notch strength. Titanium alloys appear more consistent than steels in this respect.

In the absence of stress concentration ($K_t = 1$), neither the steel nor titanium alloys investigated exhibit a pronounced loss in strength at temperatures down to −320 F. However, in the presence of stress concentrations, steel alloys show a sharp transition (rapid drop in notch strength) near room temperature. The same transition is gradual for titanium alloys.

*ASTM Paper No. 76a, "Effect of Stress Concentration on Tensile Strength of Titanium and Steel Alloy Sheet at Various Temperatures," presented at the 63rd Annual Meeting, Atlantic City, N. J., June-July, 1960, 14 pp.*

## Iron and Steel Under Impulse Loading

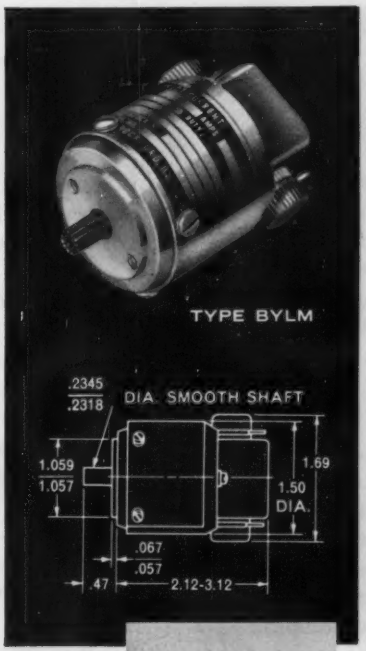
*E. G. Zukas and C. M. Fowler, Los Almos, University of California*

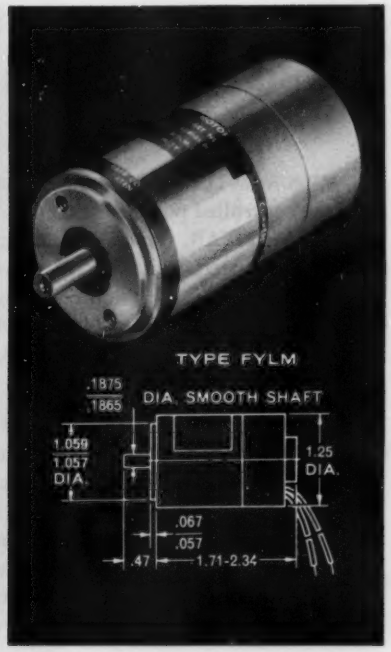
Behavior of iron under plane shock-wave loading at pressures from 45 to 750 kilobars, and the effect of prestraining by rolling or pressing on this behavior.

In annealed iron, Neumann bands (mechanical twins) are normally formed by shock loading, and appear to be formed principally by action of the Elastic I pressure wave. Shock pressures above 130 kilobars produce a polymorphic transformation in iron. Iron which has undergone this transformation, when unloaded and cooled rapidly to atmospheric temperatures, returns to essentially its original condition without evident

(*Please turn to p. 224*)


*Permanent magnet, d-c tachometer generators with high linear output . . . low ripple . . . for precision applications*




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UP TO 24 VOLTS PER 1000 RPM OUTPUT

RATED OUTPUT TOLERANCES WITHIN ±1.5%

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Circle 500 on Page 19

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**MINIMUM LUBRICATION REQUIRED** —Because of the controlled porosity and non-melting nature of GRAPHITAR, the only lubricant GRAPHITAR bearings need is water or other low-viscosity fluid. Any such fluid with non-gumming characteristics will provide an extremely low coefficient of friction and assure long life of the GRAPHITAR parts.

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**MECHANICALLY STRONG** — GRAPHITAR will not warp or distort even in high pressure applications. Compressive strength up to 45,000 psi and transverse breaking strength from 3000 to 16,000 psi, depending on the grade.

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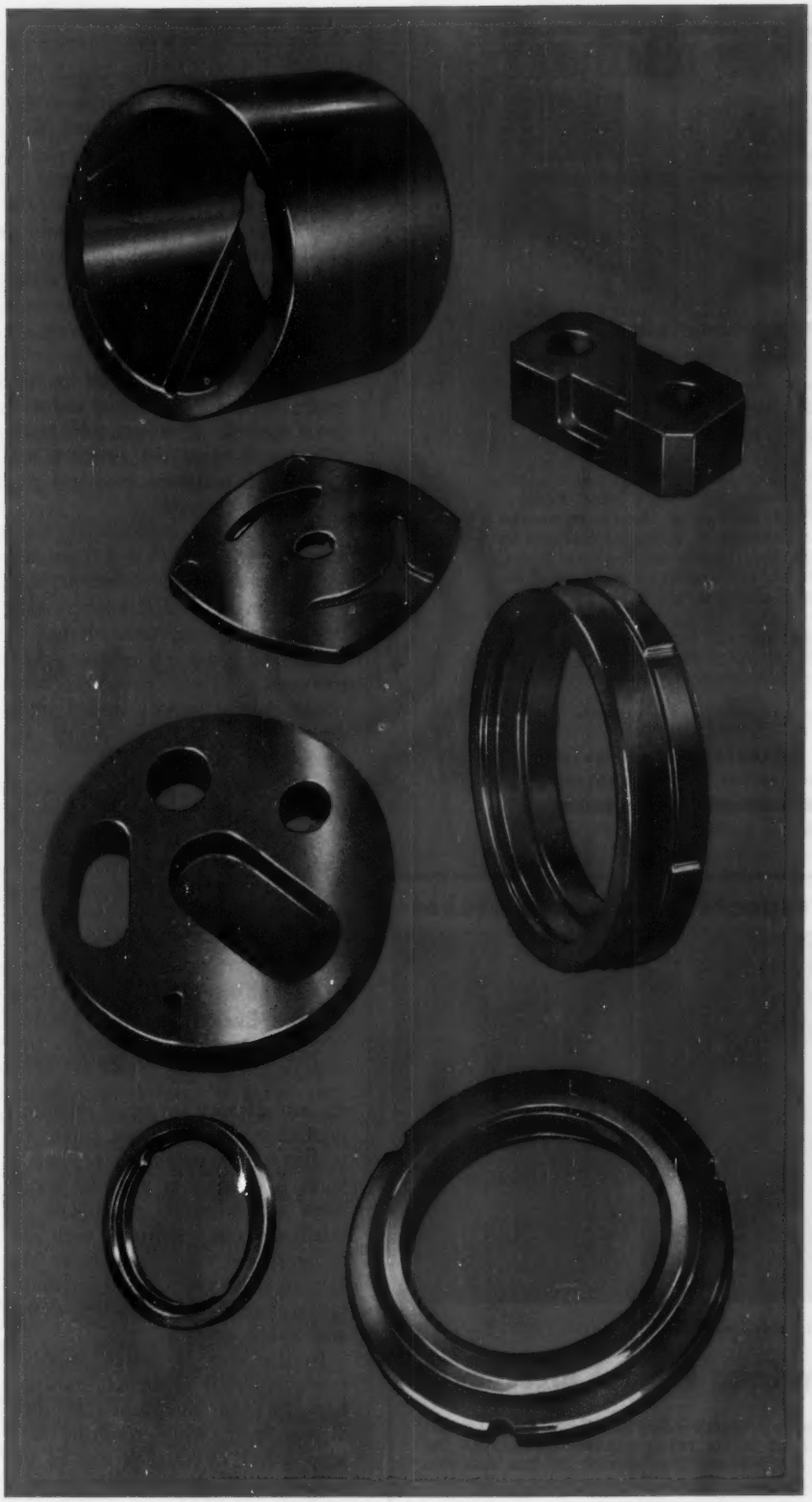
**MOLDABLE** —GRAPHITAR has excellent moldability properties that make possible and practical unusual shaped parts. Design requirements such as ears, face slots, and outside diameter notches can easily be incorporated into GRAPHITAR parts without secondary machining and finishing operations.

**MACHINING** —The United States Graphite Company operates an excellent finishing department to do all finishing operations to the most exacting specifications. GRAPHITAR may be ground to size or shaped with a tungsten carbide or diamond tipped tool to tolerances as close as .0005". When surfaces require a high degree of precision in flatness, lapping and polishing equipment are employed and accuracies within three light bands can be produced.

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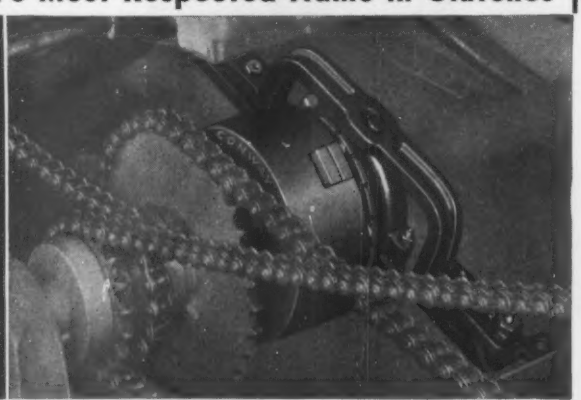
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(Continued from p. 221)

changes in crystal orientation or destruction of previously formed Neumann bands.

Iron prestrained 25 per cent or more by either pressing or rolling does not twin when pressed at liquid nitrogen temperature immediately after prestraining. However, if permitted to age at room temperature after prestraining, it slowly regains its ability to twin. Similar effects are observed for iron which has been prestrained and then shock loaded. Previous cold working also changes the pressure and velocity of both the Elastic I and the Plastic I waves.

Specimens of commercial steels containing from 0.25 to 1.0 per cent carbon were shock loaded at pressures from 45 to 750 kilobars after either annealing, quenching, or quenching plus tempering heat treatments. Twin markings were observed on all shock loaded specimens which had been either annealed or spheroidized.

*Paper titled "The Behavior of Iron and Steel under Impulse Loading," presented at the Conference on Response of Metals to High Velocity Deformation, Estes Park, Colo., July, 1960.*

## techniques

### Reliability Prediction As a Design Tool

*Thomas C. Reeves, Defense Electronics Products Div., RCA*

An introductory survey of reliability prediction, in three main parts: Introduction to reliability prediction, what it consists of and the conditions which must accompany its intelligent use; validity of such predictions; and uses of reliability predictions in operations analysis, maintenance and logistic studies, design and value analysis.

In the area of design improvement, reliability prediction finds perhaps its most important role. Prediction itself, while resulting in a very useful number, is not as important as thorough and objective analysis of the design which must be made to derive that number. The circuit-by-circuit, part-by-part study of performance requirements under assumed stresses and part capabilities is a screening which identifies outright design oversights

and marginal applications. In both instances, reliability analysis which precedes the prediction yields recommendations for timely corrective action before design release.

This independent review provides an important built-in-element of design discipline. Original design becomes *more* self-critical (not less) when a program of independent design review and reliability analysis is undertaken. One might say, that the objective of reliability engineering is to bring the reliability problem under such a degree of control that reliability engineers will no longer be needed.

*ASME Paper No. 60-MD-1, "Reliability Prediction—Its Validity and Application as a Design Tool," presented at the Design Engineering Conference, New York, May, 1960, 8 pp.*

## mechanical

### Properties and Applications Of Shock Waves

*George E. Duvall, Stanford Research Institute*

Qualitative descriptions of detonations and the shock waves they produce in inert materials.

Equations of the shock transition are given and applied in an example to obtain the amplitudes of shocks produced in several solids. Methods for measuring the equations of state of solids with shock waves are described and the reflection of a shock wave at a free surface is discussed. It is shown how phase transitions in materials give rise to multiple shock waves and how these, in turn, can be used to study transitions.

There are unexplained discrepancies between static and shock-induced phase transitions. Explanation of these may shed new light on the mechanism of transition.

Plastic yield is also shown to produce multiple shocks in solids, one of which is an elastic wave. Measurements of this forerunning elastic wave have been reported by several investigators, and these are presented as dynamic yield strengths, which are compared to static values. Results indicate the plastic yield mechanisms to be similar in static and shock phenomena. Experimental methods for shocking



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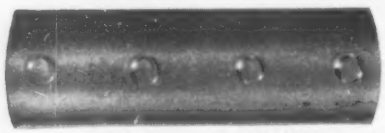
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samples are described and some results of terminal observations on such specimens are discussed.

*Paper titled "Some Properties and Applications of Shock Waves," presented at the Conference on Response of Metals to High Velocity Deformation, Estes Park, Colo., July, 1960.*

### Crank-Piston Gas-Generator Locomotive

*L. H. Tengner, Aktiebolaget Gotaverken, Goteborg, Sweden*

Application and special features of the compound piston-and-turbine engine, called a gas-generator, in railway service.

In the free-piston engines the movement of the pistons is not restricted by mechanical means. In the crank-piston types the pistons are connected by rods to one or several crankshafts, fixing their stroke and end positions.

In this prototype locomotive, the gas generator is a 2-stroke opposed-piston engine with reciprocating compressors. The power engine is a gas turbine fed from the gas generator. The compressor pistons of the gas generator are crank-bound, which means that the dead centers of the pistons are fixed. This makes it possible to make the clearance between the compressor piston and the compressor cover very small. With increasing load and scavenge air pressure, both compression and combustion pressures rise to values not tolerable in a diesel cylinder. To avoid this, the gas generators are equipped with a compression regulator, which changes the compression ratio according to the load and achieves a substantially constant combustion pressure over the main part of the load range.

*SAE Paper No. 214C, "Crank-Piston Gas-Generator Locomotives," presented at the SAE National West Coast Meeting, San Francisco, August, 1960, 14 pp.*

## hydraulic

### Two-Dimensional Gas Jets

*M. J. Cohen, Senior Lecturer, Northampton College of Advanced Technology, London, England*

A method for solving certain problems of subsonic aerodynamic de-

sign where flow boundaries in the physical plane are required to have specific dynamic characteristics.

The method is tested on two type-problems with known exact solutions: The two-dimensional gas jet, and the flow in the neighborhood of stagnation points. It is found to give the solution with a degree of accuracy acceptable for practical design.

*ASME Paper No. 60-APM-27, "Two-Dimensional Gas Jets," presented at the Summer Conference of the Applied Mechanics Division, University Park, Pa., June, 1960, 6 pp.*

## Thermal Stresses in a Plastic-Elastic Cylinder

*H. G. Landau, Research Associate in Mechanical Engineering, Columbia University, and E. E. Zwicky, Jr., supervisor, Stress Analysis Engineering, General Electric Co.*

Equations for the stress rates in solid cylinders subject to transient temperature distributions, based on the assumption of an elastic, perfectly plastic material obeying a temperature-dependent yield condition.

A numerical procedure for integrating the equations is developed and applied to a temperature distribution approximating a phase transformation and to a quenched cylinder. The effects of various factors on the residual stresses are noted.

*ASME Paper No. 60-APM-4, "Transient and Residual Thermal Stresses in an Elastic-Plastic Cylinder," presented at the Summer Conference of the Applied Mechanics Division, University Park, Pa., June, 1960, 8 pp.*

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*ASTM*—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Conference on Response of Metals to High Velocity Deformation, Estes Park, Colo.

*SAE*—Society of Automotive Engineers, Inc., 485 Lexington Ave., New York 17, N. Y., papers 50 cents to members, 75 cents to nonmembers.


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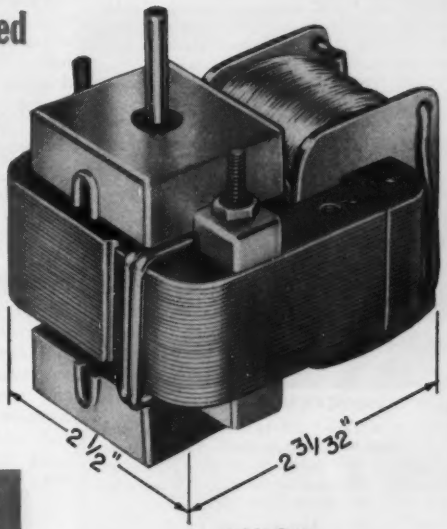
AC MOTORS

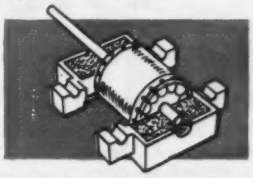
1/1800 H. P. TO 1/35 H. P.

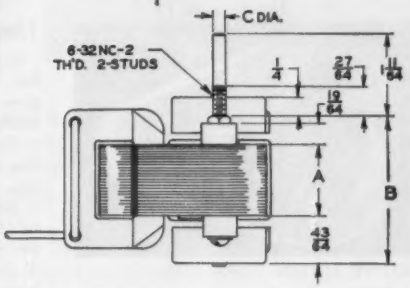
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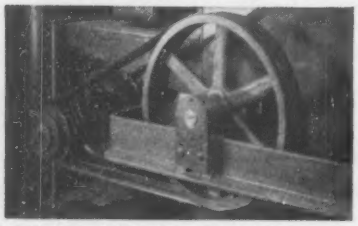
| MODEL | HP 2800 RPM | Locked Torque in./oz. | Max. Torque in./oz. | Free Speed RPM | Amps Free | Watts Free | A | B | C | Wt. Lbs. |
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| H-6-CW H-6-CCW | 1/150 | 1.40 | 2.20 | 3375 | .270 | 12.5 | 3/4" | 1 53/64" | .1817" | 1.8 |
| H-7-CW H-7-CCW | 1/110 | 1.55 | 2.50 | 3400 | .290 | 13.0 | 7/8" | 1 61/64" | .1817" | 1.9 |
| H-8-CW H-8-CCW | 1/100 | 1.85 | 3.00 | 3400 | .300 | 15.0 | 1" | 2 5/64" | .1817" | 2.0 |
| H-9-CW H-9-CCW | 1/80 | 2.00 | 3.50 | 3425 | .335 | 17.5 | 1 1/8" | 2 13/64" | .1817" | 2.4 |
| H-12-CW H-12-CCW | 1/70 | 2.20 | 4.35 | 3450 | .390 | 18.0 | 1 1/2" | 2 37/64" | .1817" | 2.8 |
| H-14-CW H-14-CCW | 1/55 | 2.30 | 4.70 | 3490 | .395 | 21.0 | 1 3/4" | 2 53/64" | .250" | 3.3 |
| H-16-CW H-16-CCW | 1/50 | 3.00 | 5.00 | 3490 | .400 | 25.0 | 2" | 3 3/64" | .250" | 3.8 |

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## WOOD'S POWER TRANSMISSION PRODUCT NEWS



NEW, NON-FREEZING VARIABLE

Wood's new "SVS" stationary control, variable speed drive has positive locking collars and other, patented features which eliminate freezing, assure easy speed change. No lubrication is required. Uses standard v-belts and stock companion sheaves. Write for Bulletin 6102.

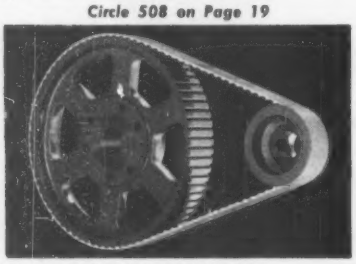
*Circle 507 on Page 19*



NEW, TREMENDOUS SAVINGS

Wood's new Ultra-V Drives handle up to 3 times more horsepower than conventional v-belt drives in a given space... reduce overall drive dimensions as much as 50%... cut weight up to 25% and costs up to 30%. Write for Bulletin 9102.

*Circle 508 on Page 19*



POSITIVE ACTION—LONG LIFE

Wood's Timing Belt Drives provide positive, slip-free action. Belts are all muscle. No high initial tension, tension devices or lubrication needed. Drives are light weight, compact... quiet and clean. Wide load and speed range. Equipped with famous Sure-Grip Bushings. Write for Bulletin 2100.

*Circle 509 on Page 19*

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# Helpful Literature for Design Engineers

**For copies of any literature listed, circle Item Number on Yellow Card—page 19**

### Ball Bearings

Data Sheet 6007 gives complete dimensional and performance specifications for miniature extended inner-ring ball bearings. Each type is pictured in a line drawing, and a table presents all specifications. Manufactured to tolerances of ABEC Class 5 and better, bearings are particularly useful where it is desirable to eliminate spacers or controlled shoulders on shafts. 2 pages. Miniature Precision Bearings Inc., Precision Park, Keene, N. H.

*Circle 701 on aPeg 19*

### Fasteners

Latest additions of die-cast zinc-alloy and molded-nylon fasteners are described in Bulletin 2002-1. Bulletin includes descriptions of integral washer-base fasteners and molded nylon and plastic-headed fasteners. Full dimensional information and pictures are provided. 2 pages. Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.

*Circle 702 on Page 19*

### Timing Belt Drives

Bulletin 21103, "Five Simple Steps to the Selection of Timing Belt Drives," gives a method involving a minimum of mathematics for the selection of a drive to fit any application. Bulletin includes five sets of curves for drive-width selection, and a standard timing-belt catalog is the only outside reference needed. Method of computation is illustrated by a sample problem, followed through for each of the five steps. 8 pages. T. B. Wood's Sons Co., Chambersburg, Pa.

*Circle 703 on Page 19*

### Photoelectric Scanner Relay

Complete description of new photoelectric scanner relay is provided in Bulletin PE-5. Relay provides an adjustable time delay between the changing of light, and is suitable for light or dark operation. Details include photographs, dimensions, applications, and adjustment. 2 pages. Farmer Electric Products Co. Inc., 2300 Washington St., Newton Lower Falls, Mass.

*Circle 704 on Page 19*

### Plastic Tubing

Bulletin 660 lists dimensions, operating data, and other product details for four types of tubing: Three formulations of vinyl-base tubing for laboratory, food, and aromatic-hydrocarbon applications; air hose; polyethylene tubing for instrumentation and general use; two weights of nylon tubing for 1000 and 2500-psi pressures. Features of the products are pointed out, including physical properties, chemical resistance, and applications. 4 pages. Munray Products Div., Textron Inc., 12400 Crossburn Ave., Cleveland 35, Ohio.

*Circle 705 on Page 19*

### Geared Speed Reducers

Brochure F-2003 contains technical information on shaft-mounted, geared speed reducers as well as illustrations, feature descriptions, and selection and ordering instructions on Shaftmount Synchrogear. Tables show service classifications to be applied in determining types of speed reducers to be used in numerous industrial applications. Frame-size selection tables are provided for each of three service classifications. Also provided are high and low gear ratios for each horsepower and frame size, with preferred ratios for specific rpm indicated. There are also dimensional drawings and tables for the respective frame sizes. 12 pages. U. S. Electrical Motors Inc., P. O. Box 2058 Terminal Annex, Los Angeles 54, Calif.

*Circle 706 on Page 19*

### Electrical Conductivity

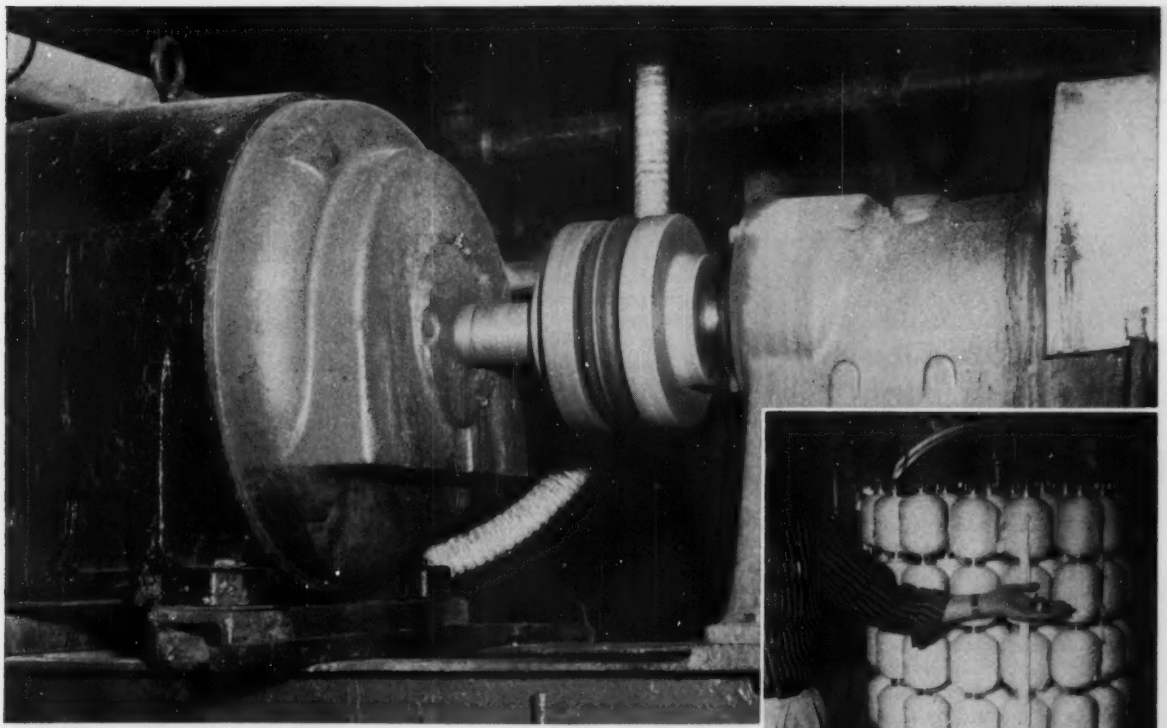
"Bridgeport Metals and Electrical and Electronic Apparatus" provides a check list for electrical conductivity ratings of 56 copper alloys. Listed also are available mill shapes for each alloy, and typical uses in electrical and electronic apparatus based on physical and mechanical property characteristics. 8 pages. Bridgeport Brass Co., 30 Grand St., Bridgeport 2, Conn.

*Circle 707 on Page 19*

### Circuit Breakers

Bulletin 5001-1A describes a complete, diversified line of molded-case circuit breakers. Illustrated two-color bulletin gives ratings, specifications, and operating characteristics as a guide in selecting breakers for a wide variety of applications. Two-page reference chart pictures each type of breaker and gives at a glance complete information on ratings, overcurrent devices, accessories, and modifications. Other tables furnish sample UL specifications and test requirements. Many photographs and cut-away drawings are included. 40 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.

*Circle 708 on Page 19*





# $33 SPENT $1,500 SAVED!

Virginia Mills, Swepsonville, N. C. manufacturer of upholstery materials, bought the Sure-Flex Coupling for its readily recognized, vibration-absorption, no-maintenance, no-lubrication features. They didn't count upon one of the "plus features" of this No. 10, $33 coupling to save them $1500 and six weeks downtime. It happened like this . . .

A wing nut, used to lock the carrier of yarn into a dye vat, worked loose, passed a strainer and into the dye pump. Damage amounted to $1500. Six weeks of expensive downtime were required to replace the pump, which was driven by a 75 horsepower motor through a flexible coupling.

Shortly after installing a Sure-Flex Coupling, another nut passed into a dye pump. The coupling wound up so tightly that the flexible member jumped out of the flanges, disconnecting the pump from the motor. Inspection showed no damage. The pump and the coupling were put back into service, the latter with its original flexible sleeve. Virginia Mills is now standardizing on Sure-Flex Couplings.

This "safety factor" is just one of many bonus features that you get with Sure-Flex Couplings. More important are its 4-way flexing action which absorbs all types and combinations of misalignment, and from 5 to 15 times more shock and vibration than other leading flexible couplings, its lack of wear and its simple, trouble-free design. And the cost is low. Get the complete story.

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*write for bulletin 5103*

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SF/160

(Advertisement) No. 17 of a series



## Eastman 910 Adhesive solves another production bottleneck

Hill, Brown Fabrics Company, of Clifton, New Jersey, operate approximately 100 Jacquard weaving looms.

Once started, a loom operates round-the-clock until the weaving run is completed. Occasionally, however, a tooth on the cast iron comb-like Griff Rack breaks. In order to repair the rack by brazing it must be removed from the loom, causing shipments to be delayed by as much as a day.

Company engineers find they can now effect a temporary repair within minutes without removing the rack from the loom by using quick-setting, high-strength Eastman 910 Adhesive and thus complete the run on schedule.

Eastman 910 Adhesive is making possible more rapid repairs; faster, more economical assembly-line operations and new design approaches. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?




For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9109 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-9, Kingsport, Tenn. (Not for drug use)
*See Sweet's 1960 Prod. Des. File, 7/E*

Circle 511 on Page 19

HELPFUL LITERATURE

### Hose Fittings

New illustrated catalog of low-pressure, reusable hose fittings and one and two rayon-braid hose gives all sizes and specifications. It also contains data on reusable, low-pressure hose couplings, union swivel adapters, hose assemblies in one and two rayon-braid types with reusable couplings, oxygen and acetylene couplings and connectors, paint-spray air-hose couplings and connections, male and female hose stems, joiners, adapters, hex-pipe nipples, and pipe-reducing connectors. 12 pages. Lenz Co., 3301 Klepinger Rd., Dayton 1, Ohio.

Circle 709 on Page 19

### Commercial Bearings

Catalog 101 includes descriptive data on 15 bearing types, ranging from standard stud, bore, and flange bearings to garage-door rollers, nylon-rimmed bearings, and Rollset line. Complete dimensional information and illustrations are given for each type of unit. 16 pages. General Bearing Co. Inc., 63 Roselle St., Mineola, N. Y.

Circle 710 on Page 19

### Spiral Bevel Gears

Bulletin SPG gives full engineering data, sizes, and specifications on standard spiral bevel gears available from stock. Ratios cited are 1:1, 2:1, 3:1, 3:2, and 4:3. Gear sizes are 1.0 to 13.5 in. 4 pages. Arrow Gear Co., 2301 Curtis St., Downers Grove, Ill.

Circle 711 on Page 19

### Flexible Couplings

New brochure explains Hi-Cap flexible coupling construction details, and gives complete specifications and prices. Couplings are shaft-rated to permit selection by shaft diameters. Large photograph is used to point up the important features of the couplings. Section on how to select the couplings is also included. 6 pages. Diamond Chain Co., 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 712 on Page 19

### Steel and Cast-Iron Collars

New folder describes Hallowell steel and cast-iron collars used on moving parts and equipment. Bulletin points out advantages and features of the units, and provides specifications for solid-steel collars, and for solid and split cast-iron collars. 4 pages. Industrial Fastener Div., Standard Pressed Steel Co., Jenkintown, Pa.

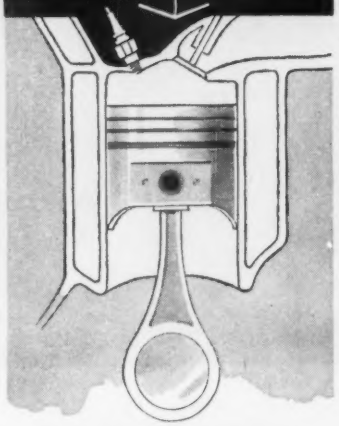
Circle 713 on Page 19

### Terminals and Connectors

Catalog 60, printed in two colors, contains illustrations, dimensional drawings, and complete data on a line of terminals and connectors. Handy reference charts for wire sizes, stud and stud-hole sizes, and decimal equivalents appear on the last pages. 28 pages. Electric Terminal Corp., P. O. Box 2217, Providence 5, R. I.

Circle 714 on Page 19

ENGINE DESIGNERS
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PISTONS

Do you know that a set of Gillett & Eaton Oil Absorbing Vanasil pistons ran more than 2500 hours in a heavy duty tractor *without any increase of blow-by?* This is a 40% increase in life over standard pistons.

In addition to Oil Absorbing Vanasil pistons, G & E makes tested and proven Aluminum Alloy, Hi-Tensile Iron, Bi-Metal and Insert Types in all sizes. Write for information on the performance you can expect from each type.

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Circle 512 on Page 19



*special application*

MOYNO® PUMPS

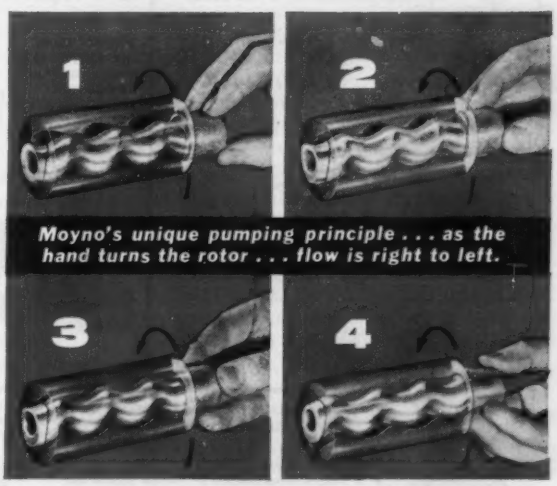
# *New special application* MOYNO® *pumps solve many product problems!*




Here is a completely new concept in small pumps. These Moynos successfully handle materials ranging from watery liquids and abrasive slurries to large particles in suspension. They use a single moving pumping element . . . have no pistons, valves, high-speed impellers or other quick-wearing parts. Moynos easily handle solids and abrasives that ruin piston pumps. They minimize sealing surface problems common to rotary pumps . . . don't cause foaming and aeration like centrifugal pumps do.

Moyno Special Application Pumps are available in two basic designs, each with or without direct-connected motor, in capacities up to 1200 gph and pressures to 300 psi. If your pumping requirements are so special that custom-designed Moynos are indicated, our engineers will examine your problem and recommend Moynos specifically suited to your needs.

Write today for copy of new Moyno bulletin 55-MD



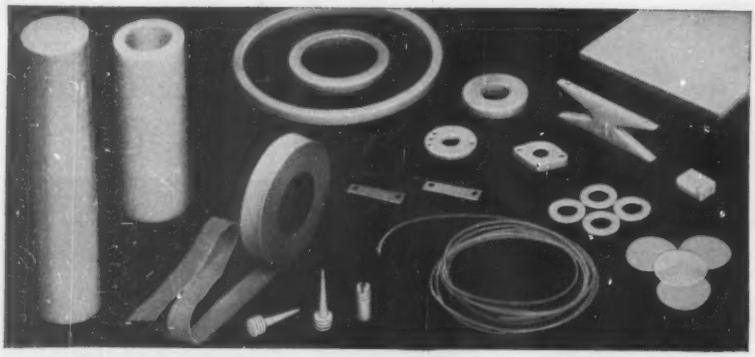

*Moyno's unique pumping principle . . . as the hand turns the rotor . . . flow is right to left.*

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*Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.*



*Circle 513 on Page 19*



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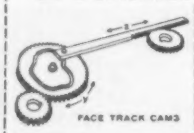
**enflo** CORP., Route 73 and Fellowship Road, Maple Shade, N. J.

*Circle 514 on Page 19*

**CAMS**

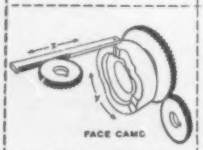
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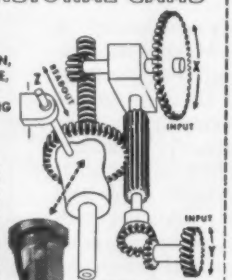




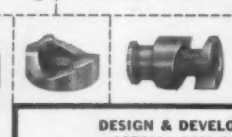
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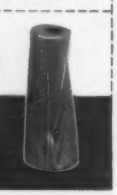
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*Circle 515 on Page 19*

HELPFUL LITERATURE

### Drafting Film

New process of restoring the printability of original tracings by washing them with soap and water is described in "Tracings You Can Wash." Included with the bulletin is a free sample of washable Herculene drafting film plus a Duralar pencil which makes a waterproof plastic line. Bulletin gives instructions on how to make the wash test after soiling the tracing with dirt and graphite. 4 pages. Keuffel & Esser Co., Third & Adams Streets, Hoboken, N. J.

*Circle 715 on Page 19*

### Industrial Springs

"Alco Springs for Industry" contains formulas, drawings, data, and illustrations for all types of hot and cold-wound springs. There also is a section outlining such considerations of spring design as working stress, modulus, and design stress. An accompanying table sets forth the physical properties of spring materials. 8 pages. Alco Products, Dept. 906-R, Box 1065, Schenectady, N. Y.

*Circle 716 on Page 19*

### Flow Meters

Two types of rugged magnetic and electronic instruments for accurately measuring fluid rates of flow and warning of abnormal flow rates are described in Bulletin 18A. Bulletin presents simplified, easy-to-follow data on application, construction, and operation, as well as tables that give dimensions, sizes, and capacities. Sectional drawings illustrate components and explain fail-safe operation. 4 pages. Dept. M-S, Instrument Div., Schutte & Koerting Co., Cornwells Heights, Bucks County, Pa.

*Circle 717 on Page 19*

### Air-Control Valves

Two-color, illustrated specification catalog covers Inline two, three, and four-way valves, and sub-base mounted four-way and four-way, five-port valves. Catalog features valve-selection tables and parts tables, and cut-away drawings of valves showing design and construction. There is also information on installation and maintenance, and on conversion of valves to external pilot supply. 40 pages. Hoffman-Odom Co., 2360 W. Dorothy Lane, Dayton 39, Ohio.

*Circle 718 on Page 19*

### Ball Retainers

Catalog 2 contains information on cup and cone retainers, single-piece thrust retainers, medium-duty metric thrust retainers, and thrust bearings. It also includes steel thrust washers, ribbon retainers for radial bearings, retainers for deep-groove bearings, linear retainers, and pressed-steel bearings. Photographs are used to show the types of units, together with typical applications. Tables present all dimensional data. 12 pages. National Bearings Co., Flory Mill Road & Manheim Pike, Lancaster, Pa.

*Circle 719 on Page 19*

### Boxes, Covers, Cases

Complete data on magnesium boxes and covers and military transit-instrumentation cases are presented in Catalog G60. Catalog also lists various types of standard or custom accessories available, including shock-mounting and environmental-protection techniques. Drawings and tables provide complete dimensional information. 24 pages. Zero Mfg. Co., 1121 Chestnut St., Burbank, Calif.

*Circle 720 on Page 19*

### Mechanical Shaft Seals

New three-color folder describes and illustrates two designs in general-purpose mechanical shaft seals, Types KFA and KFB. Type KFA is for use in applications where the housing bore is a limiting factor, and Type KFB is for applications where axial length must be kept to a minimum. Folder shows cut-away views of the seals, and includes a list of minimum mounting dimensions as well as a list of recommended seal materials for various media. Also included are typical applications and a brief explanation of the sealing principle of rotary seals. 8 pages. Rotary Seal Div., Muskegon Piston Ring Co., Sparta, Mich.

*Circle 721 on Page 19*

### Miniature Pushbuttons

Bulletin GEA-7127 describes a complete line of industrial miniature oiltight pushbuttons. Illustrations and photographs describe the flexibility and appearance advantages of the new line, and show how it can reduce panel-space requirements at least 40 per cent. Dimensional ratings, outlines, and drawings are provided. Various forms available are shown along with stations and enclosures. Ordering information is also given for each form, including pushbuttons and selector switches, illuminated pushbuttons, indicating lights, push-to-test lights, enclosures, and pendent stations and accessories. 10 pages. General Electric Co., Schenectady 5, N. Y.

*Circle 722 on Page 19*

### Steam Traps

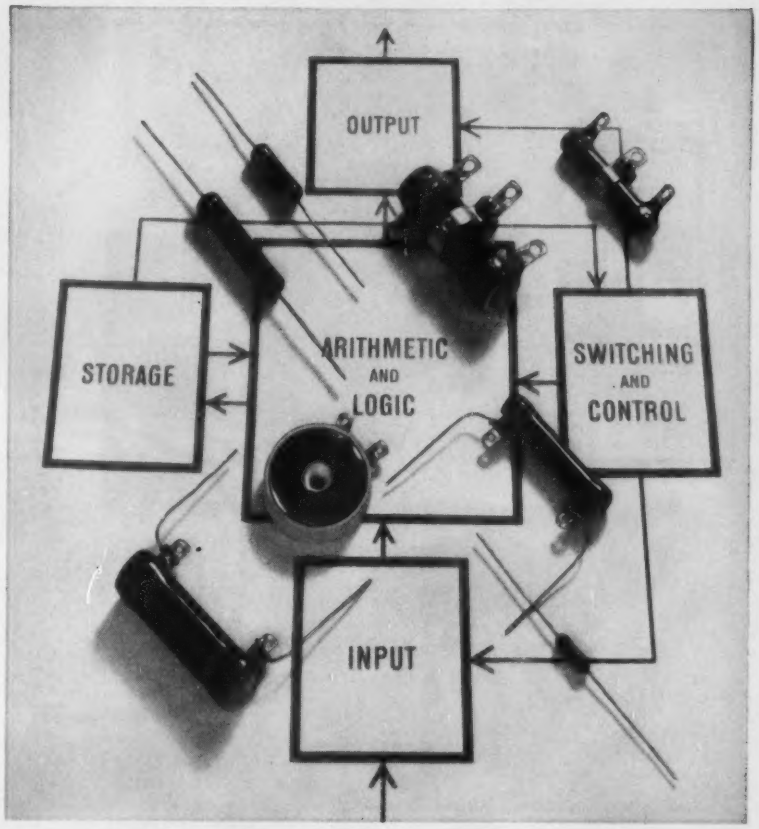
Condensed catalog contains technical details, dimensions, and capacity data on steam traps, temperature regulators, and heating specialties. Cut-aways and photographs are liberally used to point out features and provide dimensional data. 12 pages. Sarco Co. Inc., 635 Madison Ave., New York 22, N. Y.

*Circle 723 on Page 19*

### Screw-Conveyor Drive

Standard double-reduction, shaft-mounted, speed-reducer drive for direct application to screw conveyors is the subject of Folder 2718. Reducer is available in six sizes with ratios of 15:1, 20:1, and 24:1 for motors to 30 hp. Folder lists sizes available in relation to screw diameters, and gives selection data. 4 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

*Circle 724 on Page 19*


*In modern digital computers*

**PERFORMANCE IS THE PAY-OFF**

**A big, modern digital computer may cost as much as $10-million to buy outright. Even rental may run as high as $50,000 a month.**

**With money like that involved, computer-makers can't take a chance on substandard components. They want, and get, the best components.... the best resistors. Where wire-wound power resistors are required, they frequently specify Ward Leonard VITROHMS.**

**There's another reason, too, why computer manufacturers want only the best: They're shooting for 99.99...% statistical reliability of *components*, and the more "9's" the better. Computer components—say, resistors—are numbered in the tens of thousands, and they have to have this kind of performance to get 99.8% reliability in their final product. For this reason, computer makers insist on, and get, *performance*—as continuous and reliable as the state of the art permits. And again, where wire-wounds are required, they are likely to specify Ward Leonard VITROHMS.**

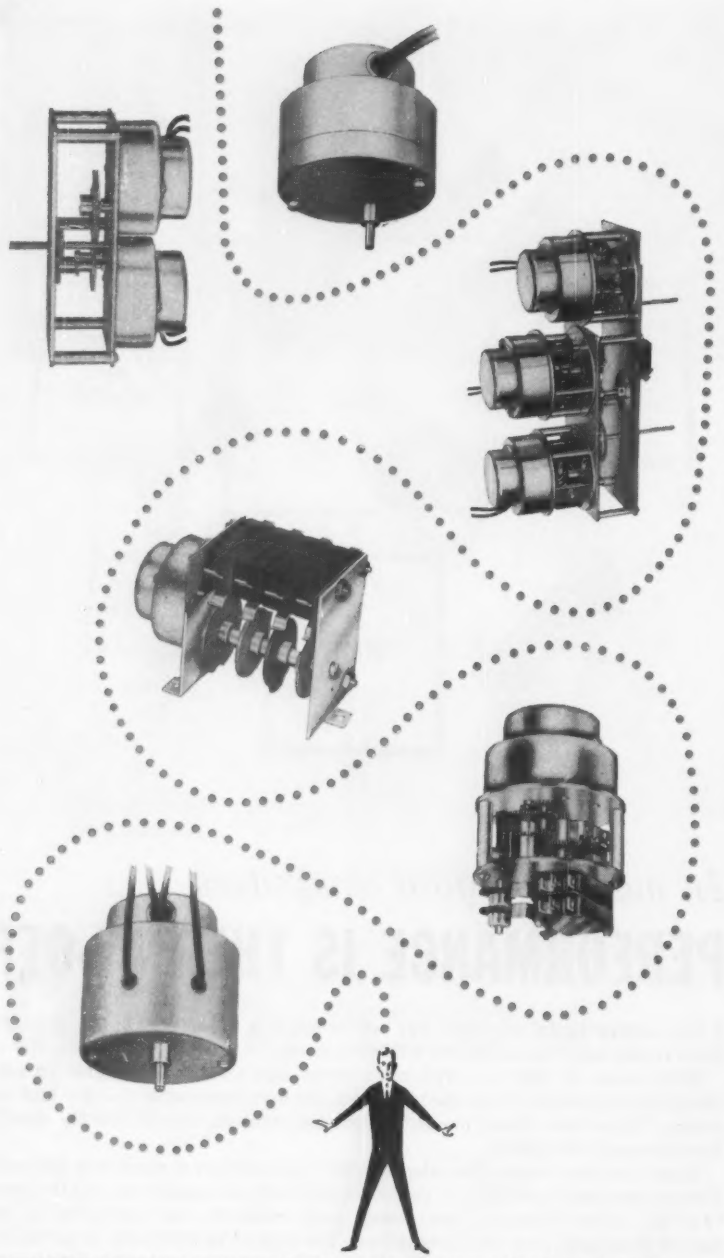
**If you want maximum quality and maximum reliability in your product, follow the lead of outstanding digital computer manufacturers—like IBM, Remington Rand, and Burroughs—and specify W/L VITROHMS. You'll find full information in catalog D130. Write for your copy, and the name of your nearest VITROHM distributor, today. Ward Leonard Electric Co., 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)** O.6

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*Circle 516 on Page 19*



IS FINDING THE RIGHT TIMING DEVICE YOUR PROBLEM?

Call in the Man from Bristol Motors! He talks your language—knows how to meet your needs and problems. Whether you require a standard motor, a modification of a standard, or a new design, Bristol experience can be counted on to give you quick delivery of the timer best suited to your needs. A wide torque range is available—speed ranges from 1800 rpm to 1 rp month! You can get variations in shaft length, voltages, shift and brake action and other special features for your specific needs. For dependable, economical synchronous timing in industrial control and instrumentation—ask for the Bristol Motors Representative in your area.

Write for new Catalog 160.

BRISTOL (B) MOTORS

Division of Vocaline Company of America, Inc.
210 Coulter Street, Old Saybrook, Conn.
Dept. MD-9

VB-2

Circle 517 on Page 19



### Tolerance Ring

New bulletin provides information on the Star Tolerance Ring, a corrugated open ring of hardened steel. Bulletin gives information on applications and advantages. Two types are described, and graphs are used to supply data on tolerances. Sizes are listed, and line drawings are used to show some typical applications. 4 pages. Roller Bearing Co. of America, Sullivan Way, West Trenton, N. J.

Circle 725 on Page 19

### Alloys

Detailed information on alloys for abrasion, impact, corrosion, and heat-resisting services is contained in a series of data sheets. Each sheet provides complete engineering data on a single alloy, including available forms, physical properties and nominal chemical composition, typical applications, and recommended finishing procedures. 15 pages. Coast Metals Inc., Redneck Ave., Little Ferry, N. J.

Circle 726 on Page 19

### Flexible-Shaft Assemblies

Catalog 6094 illustrates light-duty flexible shafts and flexible-shaft couplings. It lists in detail many types and sizes of standard flexible shafts and couplings ready for installation, as well as popular component parts, required to design special assemblies. Typical core properties are also given for engineering evaluation. Various design techniques to assist engineers in applying flexible-shaft assemblies are included. 12 pages. Kupfrian Mfg. Corp., 382 State St., Binghamton, N. Y.

Circle 727 on Page 19

### Welded-Metal Bellows

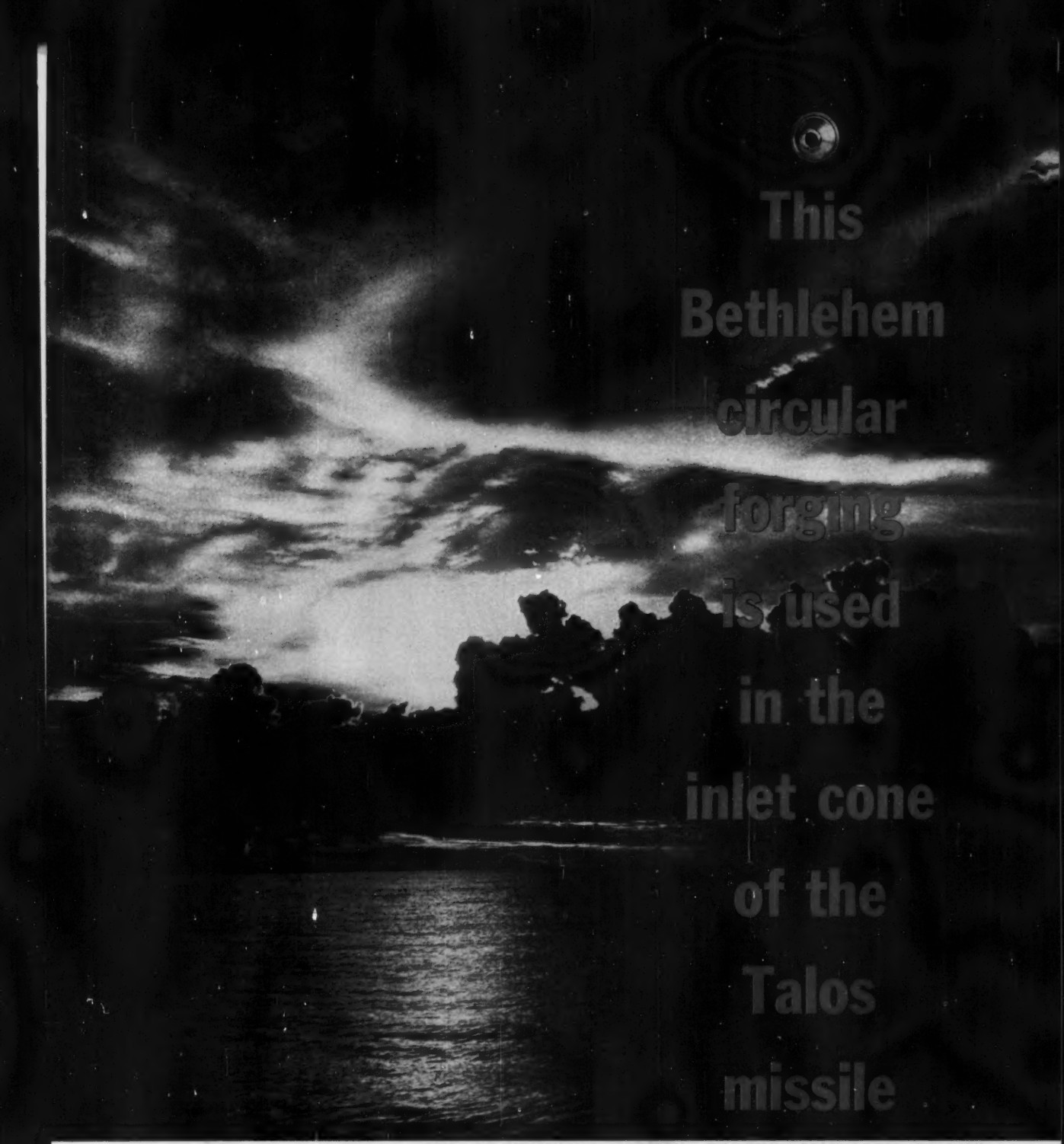
Exhaustive design data for volume-compensating welded-metal bellows are included in new, illustrated brochure. Use of the bellows for gyros, accelerometers, and other floated instruments is fully detailed, together with necessary formulas and tolerances for preparing preliminary drawings for new applications. Much design data is prepared in easy-to-use chart form with selective performance characteristics available on the chart. 4 pages. Metal Bellows Corp., Mica Lane, Wellesley Hills 82, Mass.

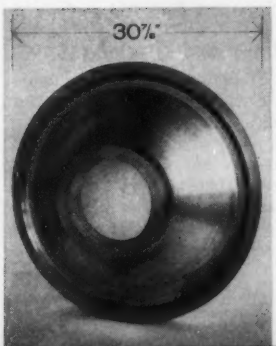
Circle 728 on Page 19

### Telephone-Type Relays

Full-color folder contains a chart showing all electrical and mechanical characteristics of the seven basic types of relays, as well as coil data and available enclosures. Also included is a nomogram upon which the operating speed of Type BS relay can be calculated, with complete explanation of how it can be used. Supplemental information such as speed, pressure conversion, and temperature-rise curves is also incorporated. 4 pages. Potter & Brumfield Div., American Machine & Foundry Co., Princeton, Ind.

Circle 729 on Page 19




Other than using magnaflux-quality steel, we make circular forgings for highly critical missiles exactly the way we make *every* Bethlehem circular forging. Same manufacturing processes. Same quality control. The success of Bethlehem circular forgings in missile inlet cones, forward heads, and adapters is just one proof of quality. If you'd like the whole story, get in touch with our nearest sales office. Or write to us at Bethlehem, Pa.

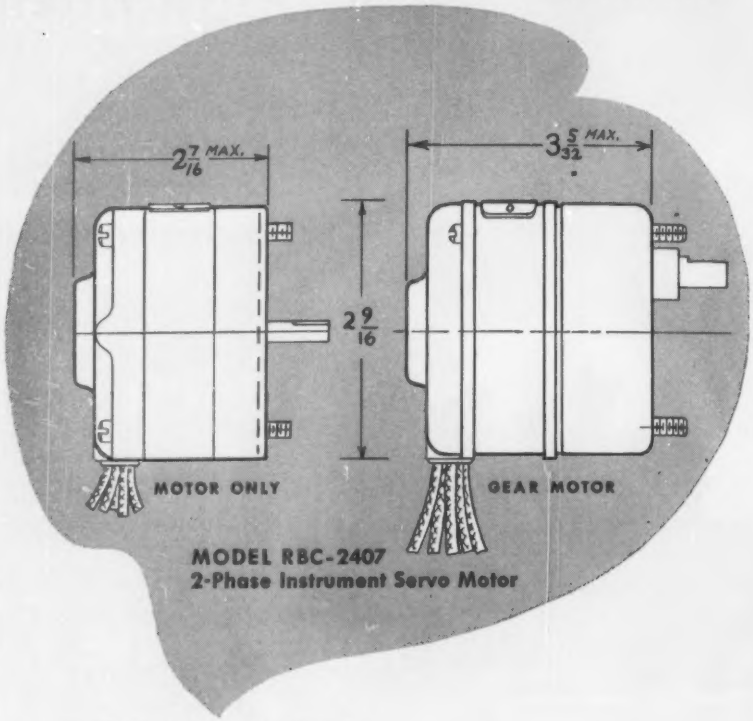
BETHLEHEM STEEL COMPANY, Bethlehem, Pa. *Export Distributor:* Bethlehem Steel Export Corporation

**BETHLEHEM STEEL**

BETHLEHEM STEEL

*Circle 518 on Page 19*

# HOLTZER-CABOT
## offers these CUSTOM FEATURES in a new stock motor




MODEL RBC-2407
2-Phase Instrument Servo Motor

- High torque-to-inertia ratio
- Torque to meet your needs
- Several output speeds to choose from
- Control winding impedance of 5400 ohms locked rotor
- New motor end cap design for easier mounting, better heat dissipation

The RBC-2407 is available as a basic motor or with four stock gear ratios to meet your application requirements. All gear motors are electrically and mechanically interchangeable. Send coupon for free bulletin covering complete details, including physical dimensions and electrical specifications of this Model RBC-2407 instrument motor.

**HOLTZER-CABOT MOTOR DIVISION • NATIONAL PNEUMATIC CO., INC.**

*Sales-Service Representatives in Principal Cities throughout the World*

*Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems*

HOLTZER-CABOT MOTOR DIVISION, Department MD
National Pneumatic Co., Inc., 125 Amory St., Boston, Mass.

Please send: ☐ Complete details of Model RBC-2407 Servo Motors
☐ Information on other H-C Instrumentation Motors

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____


HELPFUL LITERATURE

### Rulon and Teflon

Brochure 9572 describes electrical, physical, mechanical, and chemical properties of Rulon and Teflon. Brochure gives a comprehensive comparison of the properties of the two materials, and shows typical applications in such industries as textile machinery, chemical and food processing, electronics, missiles, paper making, automotive, and applicances. Numerous Rulon parts fabricated for use as lube-free bearings, thrust washers, O-rings, wear strips, valve seats, and insulators are illustrated. 4 pages. Plastics Div., Dixon Corp., Bristol, R. I.

*Circle 730 on Page 19*

### Pillow Blocks

Catalog 860 contains information on self-aligning, spherical, roller-bearing pillow blocks. Design features are pointed out and pictured in detail. Tables and line drawings provide all data on dimensions. Section is included on bearing selection, bearing life, calculated bearing life, selection of lubricant, diametral clearances, methods of mounting. 20 pages. Bantam Bearings Div., Torrington Co., South Bend 21, Ind.

*Circle 731 on Page 19*

### Cup Packings

Bulletin presents information on Vix-Syn fabricated cup packings for common metal finishes, greater machine clearances, higher operating temperatures, pressures to 10,000 psi, and acid and alkaline conditions. Line drawings are used to provide information on application and sizes. 4 pages. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

*Circle 732 on Page 19*

### Multicontact Connectors

Connectors for every need are described in colorful Bulletin 4004B. Photographs and diagrams are used to describe in detail all types of multicontact connectors and their applications. 12 pages. Electro Mechanical Instrument Div., Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

*Circle 733 on Page 19*

### Fittings and Flanges

Bulletin FB-502A describes seamless welding fitting and flanges, of carbon, alloy, and stainless. Tables provide information on sizes, types, and dimensions. Information is given on dimensional tolerances, and various types of fittings and flanges are pictured. 8 pages. Tubular Products Div., Babcock & Wilcox Co., P. O. Box 230, Beaver Falls, Pa.

*Circle 734 on Page 19*

### Hose Fittings and Assemblies

Bulletin BR-3HF on Nylaflow nylon pressure hose contains a hose selector chart and data on a complete range of reusable fittings. Instructions for applying fittings and information on ordering assemblies are included. 4 pages. Polymer Corp. of Pennsylvania, Reading, Pa.

*Circle 735 on Page 19*



*Circle 519 on Page 19*

*Circle 520 on Page 19→*




# HOW HEAVY A LOAD

## can a ball bearing carry?

Federal Ball Bearings make light work of the heaviest loads. *Quiet* work, too. We use SAE 52100 steel and engineer extra stamina into every ball and raceway. Each bearing goes through scores of production and quality control steps because, frankly, we're terrible cranks about precision. We insist that you should be able to mount a ball bearing—and forget it.

Our customers seem to like this idea. And they include the most respected names in American industry. So, when you want to take a work load off your shoulders, put it on a Federal Ball Bearing. Our catalog lists over 12,000 ball bearing sizes, hundreds of types. Send for it.

THE FEDERAL BEARINGS CO., INC., Poughkeepsie, N. Y.

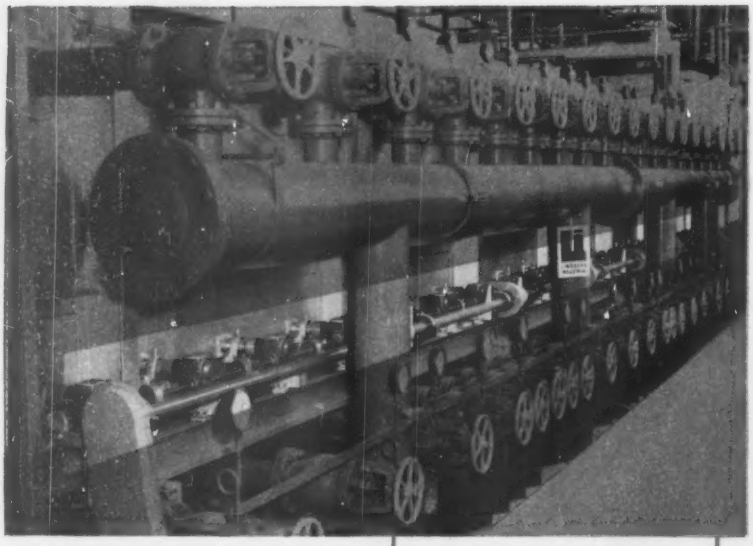
**Federal**

**BALL BEARINGS**



*One of America's largest ball bearing manufacturers*

FEDERAL ON FILM—A 16 mm. color sound film takes you through our 400,000 sq. ft. plant. Loaned free. Just ask for it.



Lindberg Roller Hearth Solution Treating Furnace, showing some of the 101 Winsmith Model 2CB Reducers which drive the rolls. An additional Model 7CT is also installed. The heating chamber of this furnace is 100 feet long with 40 feet of quench chamber.

# LINDBERG ENGINEERING USES 102 WINSMITH SPEED REDUCERS

*on their Roller Hearth Furnaces*



***LINDBERG ENGINEERING COMPANY*** of Chicago is a leading manufacturer of heat treating furnaces. When they designed this one to handle 4,000 lbs. of aluminum extrusions per hour, specifications called for 101 speed reducers to drive the rollers. They selected Winsmith for compact size, rating and their record of past performance. Lindberg is a long-time Winsmith customer. They describe the relationship this way..."We have used Winsmith Reducers for many years and have found their reliability and ruggedness ideal for use with our heat treating furnaces."

Lindberg Engineering is another one of the leading American manufacturers who specify Winsmith Speed Reducers for most applications from 1/100 to 85 hp.—in ratios from 1.1:1 through 50,000:1.

WINSMITH SPEED REDUCERS

***WRITE TODAY*** for complete selection information and engineering data. You'll see for yourself why it pays to standardize on Winsmith.

MEMBER OF AGMA

**WINSMITH, INC.**

**16 Elton Street, Springville, (Erie County), N. Y.**

Circle 521 on Page 19

HELPFUL LITERATURE

## Magnetic Clutch

Low-cost, 10 lb-ft Magneclutch is described in Bulletin EPD 6106-5. Included are details on the construction and operational features, dimensions and specifications, performance curves on heat dissipation and torque transmission, and cutaway drawings illustrating the operating principle of the clutch. 4 pages. Electric Products Div, Vickers Inc., 1815 Locust St., St. Louis 3, Mo.

Circle 736 on Page 19

## Variable-Pitch Sheaves

Catalog MVP-101 provides information on a new line of multiple-groove, variable-pitch sheaves. It includes tables of sheaves and companion-sheave specifications, and precalculated drive tables. Also incorporated are engineering data such as overload service factors, drive selection chart, use of companion sheaves, and an example of drive calculation. 24 pages. Browning Mfg. Co., Maysville, Ky.

Circle 737 on Page 19

## Molded Cable Assemblies

Molded cable assemblies for the industrial electronics industry are described in Catalog M-701. It features several types of assemblies, molded to various types of cables. Catalog also illustrates most commonly used cable assemblies. Also included are engineering considerations, design features, and special assemblies. 4 pages. Switchcraft Inc., 5555 N. Elston Ave., Chicago 30, Ill.

Circle 738 on Page 19

## Felt Applications

Some of the varied uses of 800 types of A-Plus felts are described in new illustrated booklet. Booklet describes standard, laminated, coated, and impregnated felts, and lists registered trade names of special-purpose felts. Application guide lists the areas of general felt usage. 8 pages. American Felt Co., Glenville, Conn.

Circle 739 on Page 19

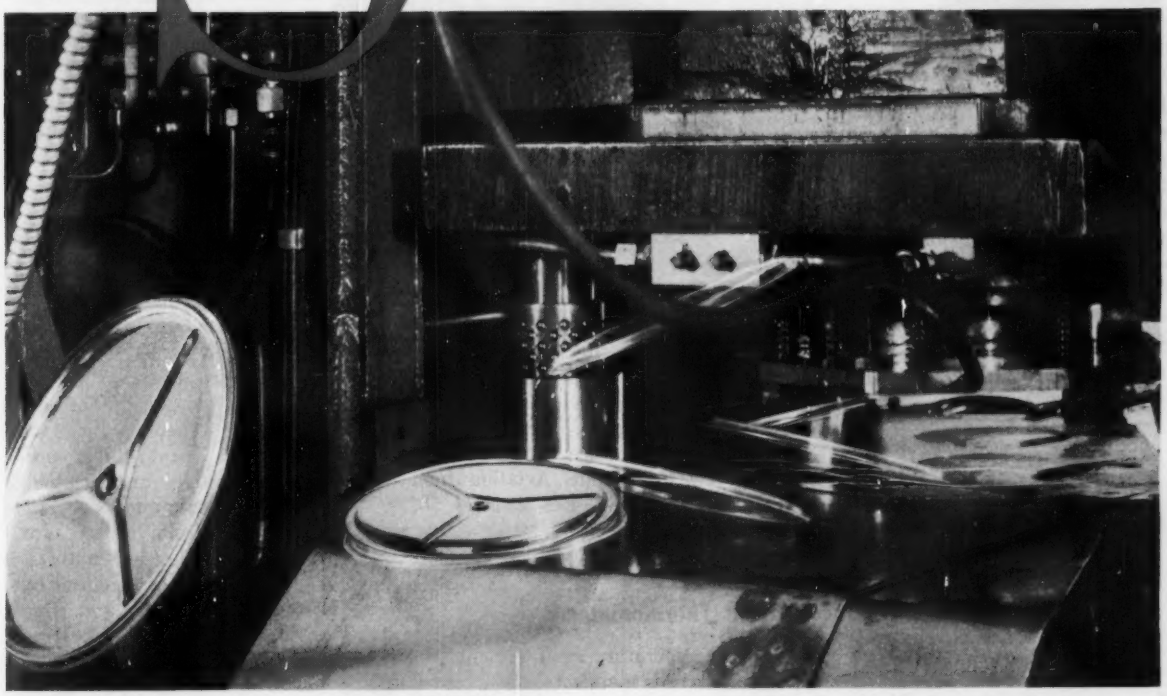
## Chains and Sprockets

Selecting a chain from horsepower tables and how to specify sprocket wheels are two examples of the information contained in new "Chains and Sprockets" Catalog 999. Catalog gives full information on 14 most popular types of chains used in industry. Hub classes, sprockets, attachments, and drive-chain data are also covered. 168 pages. Write on company letterhead to Jeffrey Mfg. Co., Columbus 16, Ohio.

## Explosive Ordnance

Technical Data Book provides information on igniters, explosive bolts, high-pressure electric terminals, pressure cartridges, gas generators, initiators, and shunts. Separate data sheets are included for each item, providing line drawings and complete specifications. Write on company letterhead to McCormick Selph Associates, Hollister Airport, Hollister, Calif.

# S *is for SPEED and SERVICE*



S

Savings and service are the prime products of speed. As units-per-hour go up, cost-per-piece comes down.

Here, high-speed, automatic equipment saves money for you, as it eats up aluminum sheet and machine-guns a flow of finished components into your production line. Schedules are met and shipments made, *on time*, because of our awareness of the importance—to *you*—of speed.

Phone, wire, or write for more information about how we can help you do *your* job faster, for less.

**MIRRO**
THE FINEST ALUMINUM



**ALUMINUM COMPONENTS**
**CUT THE COST OF QUALITY**

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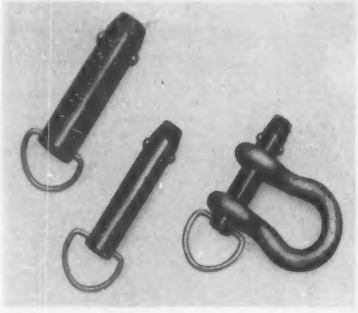
# New Parts and Materials

**Use Yellow Card, page 19, to obtain more information**

## *Quick-Release Pins*

**have large, stainless-steel lock buttons**

Eco-Pins, new quick-release pins, eliminate the need for cotter pins and locknuts. They incorporate extra-large stainless-steel lock buttons, activated by siliconized rubber, which will hold against vibration even in oversized holes. Alignment is made easier by a solid tapered end. Pins are available in sizes from ¼ in. up in stainless steel, naval



bronze, or plated steel. They can be used as clevis pins, as chain and anchor shackle pins, as safety-lock or shear-load pins, or wherever a quick-connect and disconnect pin is required. **Waldick Engineering Co.**, P. O. Box 398, Huntington Station, Long Island, N. Y.

*Circle 740 on Page 19*

## *Metering Valve*

**miniature unit has 14,000 psi burst pressure**

Small globe-type metering valve with male ports is suitable for manometer pressure gage or sampling use with gasses such as air, nitrogen, oxygen, and helium, and with liquids such as fuels, hydraulic oils, and water. Designated INS736 metering valve, it has a burst pressure of 14,000 psi. Valve body is only 0.75 x 0.75 by 1.75 in., has



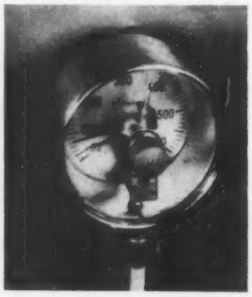
a 1.31 in. diam handle, and measures 2.75 in. high in the fully opened position. Operating torque, for fine metering and leakproof control, is 4 lb-in. at 2500 psi. Maximum operating pressure is 3500 psi, and operating temperature range is −65 to +250 F. **Robbins Aviation Inc.**, 2350 E. 38th St., Los Angeles 58, Calif.

*Circle 741 on Page 19*

## *Dial Thermometer*

**for temperature measurement on ferrous metals**

Magnetically attaching, bimetal dial thermometers for temperature measurement on ferrous materials are available in three styles: Thermometers for temperature measurement only; thermometers with maximum reset hand; and thermometers with electric contactor to permit on-off temperature control with electric resistance or induction heating. Units are available in various temperature ranges from −60 to +700 F



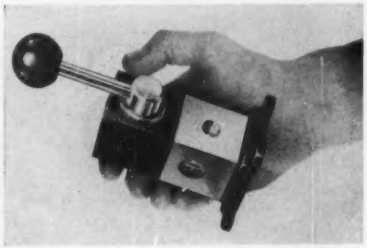
and have accuracies of better than 2 per cent. They are held to steel and other ferrous materials by permanent Al-Ni-Co magnets. **Industrial Service Co.**, 2 Richmond St., Providence 3, R. I.

*Circle 742 on Page 19*

## *Square-Body Valves*

**are compact, heavy-duty units**

Seven heavy-duty, square-body valves, operated manually and mechanically, are available for use as controls on fine-quality machine tools and in other applications where compact, heavy-duty, precision control valves are required. Valve bodies, levers, and bases are either machined from bar stock or are castings. Bodies are natural-finish aluminum, accentuated by black crackle-finish bases and trim. New models include a ball-bearing cam valve; lever and roller-type cam valve; and others operated by



a pushbutton, a large palm button, large palm button with "hold," a vertical lever, and a telegraph-key lever. All are ¼-in. size, and most are available in two-way or three-way types, normally open or normally closed. Choice of two different bases permits valves to be mounted either vertically or horizontally. Valves are for use principally with air, at pressures to 125 psi. They can be adapted for valving fluids and other gasses, as well as vacuum. Air capacity is

*Job-proved answers to your*

## EXPLOSION PROOF

*motor problems*

America's largest maker of explosion-proof gasoline motors, (70% of nation's total) offers you a wide selection of job-tested general- and special-purpose explosion-proof U/L approved motors for Class I and Class II locations.

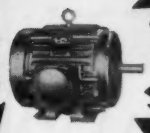
Products of *Howell Electric Motors Company, Howell, Mich.*, and *The Leland Ohio Electric Company, Dayton, Ohio* . . . A Howell subsidiary.

**TOPS FOR JOBS LIKE THESE:**

| Vapors, U/L Class I | Dusts, U/L Class II |
|---|---|
| • Hydrogen | • Metals |
| • Ethyl-ether | • Carbon |
| • Butane | • Grain |

A-2867A

⅛-100 hp



U/L APPROVED

- Single-phase
- Polyphase
- A. C. or D. C.
- Fan-cooled
- Non-ventilated

Send for Bulletins 1000 and 1015, E, F

**HOWELL**
*electric motors company*
Offices in principal cities . . . see YELLOW PAGES

Circle 523 on Page 19

*down to 1.2 rpm, to meet your "slower-than-motor"*
SPEED NEEDS

## GEARMOTORS • REDUCERS

Top-quality, job-tested Gearmotors and Speed Reducers . . . wide range—enclosures, mountings, start-run characteristics . . . A.G.M.A. Classes I, II, III.

GEARMOTORS, *parallel* shafts . . . 1—150 hp., a.c. . . . output speeds as low as 1.2 rpm.

GEARMOTORS, *right-angle drive* . . . ¼—30 hp., a.c. . . . output speeds as low as 7.3 rpm.

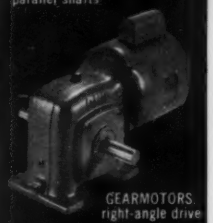
"LINE-O-DRIVE" *coupled units* . . . 1—75 hp., a.c. . . . output speeds as low as 1.2 rpm.

Products of *Howell Electric Motors Company, Howell, Mich.* and *The Ohio Electric Mfg. Company, Maple Heights, Ohio* . . . A Howell subsidiary. A-2868A

WIDE RANGE



GEARMOTORS, parallel shafts



GEARMOTORS, right-angle drive



LINE-O-DRIVE, coupled unit

• Send for Bulletin MD-1

**HOWELL**
*electric motors company*
Offices in principal cities . . . see YELLOW PAGES

Circle 524 on Page 19

*Save up to*
20%
*with K-C*

## BLOWER MOTORS

Specially developed for the air conditioning industry, this quiet-operating 2-pole, 3600 rpm motor has won wide acclaim for performance . . . and effected important savings in cost, for applications to package and remote-condenser units.

But, with no sacrifice in quality! You get time-proved K-C high quality.

Low cost is possible because all ratings are power-packed in the compact 56 frame. 1½ and 2 hp ratings (conventionally in integral-size 180 frames) suffer no loss of reserve power, carry the same 1.2 service factor.

A product of *Kingston-Conley, Inc., Plainfield, New Jersey* . . . A Howell subsidiary. A-2912A



- ½-2 hp
- 56 Frame
- 3600 rpm
- Quiet operation
- Capacitor-type
- Resilient or rigid mounting
- 1.2 service-factor
- Rugged construction

**HOWELL**
*electric motors company*
Offices in principal cities . . . see YELLOW PAGES

Circle 525 on Page 19

*• first of a series*

## WHAT YOUR HOWELL MAN

### represents and has to offer

This is a brief message to our many friends who have contributed so importantly to our growth.

Our *corporate* and *product* "Images" have changed vastly in the past few years.

Howell now also offers you the combined broad motor lines of: *The Ohio Electric Mfg. Company; Kingston-Conley, Inc.; The Leland Ohio Electric Co.*

Each is a leader in certain important areas. Each is known for certain outstanding products. Each has built on ideas, initiative, integrity.

Consolidation is now completed. *People, Plants, Products* of four formerly separate enterprises are now ONE COMPANY . . . dedicated to continued high standards of service to American Industry.

A few words about our:

### products

Howell and its subsidiaries make: MOTORS—1/40—300 hp, a.c.; GEARED DRIVES—gearmotors and coupled units, *down to 1.2 rpm;* GENERATORS—.3 to 15 KW.

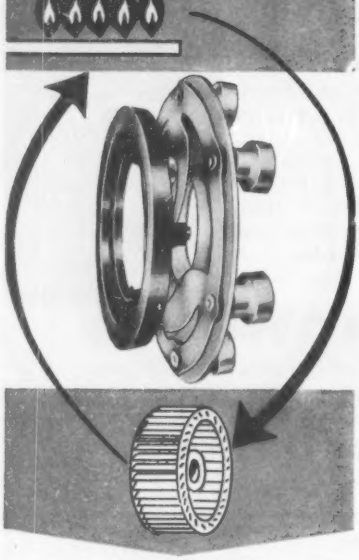
Chances are, we have what you want. If not, *we'll make it.* A-2920A

**HOWELL** *electric motors company*
SUBSIDIARIES:
OHIO ELECTRIC MFG. COMPANY • LELAND OHIO ELECTRIC COMPANY • KINGSTON CONLEY, INC.

Circle 526 on Page 19

INTERCONNECT FUNCTIONS

SYNPRO-TEX SPEED DETECTING GOVERNOR



A single SYNPRO-TEX speed detecting governor actuates fuel supply only after proper amount of air is furnished; then governor automatically shuts off fuel in event of blower failure for any reason.

This is just one example of how TORQ governors can inter-connect as well as control, sequence, and limit functions by detecting speeds.

TORQ governors can actuate at a single limit or a high and low limit in one or many speed ranges from zero to more than 15,000 rpm. They are designed on a patented principle which virtually eliminates operating friction, and which results in positive snap-action for a service life in excess of 1,500,000 cycles.

THE WORLD'S LARGEST MANUFACTURER OF SPEED DETECTORS

*Write today for Bulletin No. 250*

Patents & Patents Pending

**TORQ ENGINEERED PRODUCTS, INC.**
26 West Monroe Steet Bedford, Ohio
Phone: BEdford 2-4100

Circle 527 on Page 19



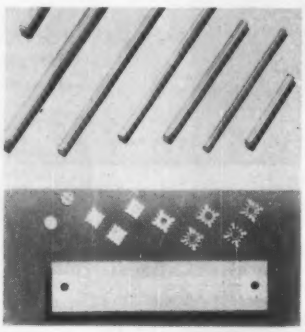

80.04 cfm at 100 psi. Valves are extremely durable. Humphrey Products Div., General Gas Light Co., Kalamazoo, Mich.

Circle 743 on Page 19

## Direct-Printed Circuits

of silver are printed on ceramics or glass

Silver circuits are now direct-printed with a high degree of accuracy on ceramics or glass. Clearly defined patterns can be applied on flats, tubes, rods, cones, and other geometric shapes for the electrical and electronic industries. Delay-line cores, micromodule wafers, and tubular capacitors are among the



many components successfully printed. In addition to precise circuit reproduction, silver inks assure a high bond strength and high scratch resistance. Heat stability to 1000 F is obtained. Circuits can be iron or dip soldered, or plated as desired. Thickness range of the circuits is between 0.0003 and 0.0010 in. In most instances, pattern tolerances can be held to ±0.002 in. J. Frank Motson Co., Flourtown, Pa.

Circle 744 on Page 19

## Spring-Loaded Seal

for pressures to 10,000 psi and temperatures to 500 F

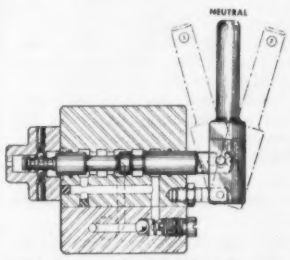
Spring-loaded, self-conforming polymer seal is available for applications in reciprocating and low-speed rotary shafts under high-pressure liquid and gas conditions. Seal combines polymer and spring steel to insure efficient operation over a temperature range of −320 to +500 F and under pressures to 10,000 psi. Seated around a shaft, seal


new 10,000 psi FOUR-WAY VALVES




effortless operation for applications up to 10,000 psi

Have valving problems on hydraulic applications calling for high pressures up to 10,000 psi? This new GREENLEE Four-Way Valve may be your answer. Simple, trouble-free spool-type valve . . . completely balanced to provide effortless operation at any pressure in any position. It operates with the same ease at 10,000 psi as at 0 psi. Panel mounted for universal adaptability. Subplate available. Precision-made, precision-tested. (Max. leakage 4 cu. in. per minute at 10,000 psi.) Write today for illustrated data sheet.




GREENLEE Four-Way Valve is available in two models: No. 1717 (above) with detent-positioned control lever . . . No. 1704 with spring-centered control lever.

*THE GREENLEE LINE ALSO INCLUDES A WIDE SELECTION OF HAND AND POWER-OPERATED HYDRAULIC PUMPS*

GREENLEE

**GREENLEE TOOL CO.**
1776 Columbia Ave., Rockford, Illinois

Circle 528 on Page 19

# Maxitorq 9000 SERIES*

# ELECTRIC CLUTCHES or BRAKES

*Featuring these*
## *Advantages:*

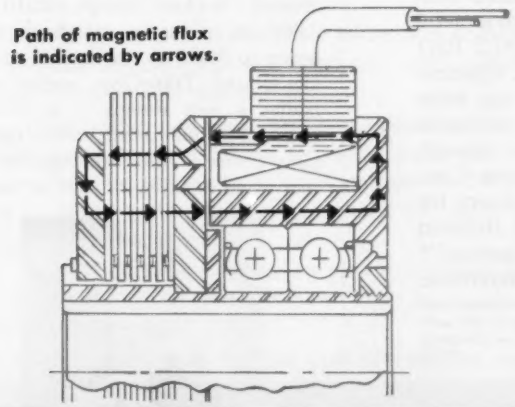
- **Compact and Simple Design**
- **Built to American Standards**
- **Stationary Coil**
- **No Slip Rings or Brushes**
- **Self-Adjusting—Easily Installed**
- **Drag-free Floating Neutral**
- **No Stressed Levers or Parts**
- **Use as Brake or Clutch**
- **Standard Flange Cups Available**



**Patent applied for.*

## OPERATION INDUCED ENTIRELY BY *Magnetic Flux*

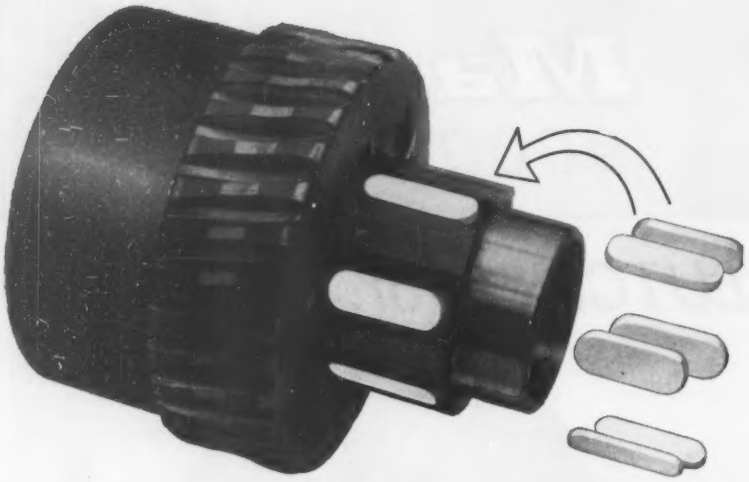
The new Maxitorq #9000 Series Electric Clutch is a compact, self-contained unit with operation dependent upon induced magnetic flux. As shown in the drawing below, this new Maxitorq Clutch consists essentially of a sealed magnetic coil and housing arrangement actuating multiple discs which also act as the flux path. Because the coil housing, supported on anti-friction bearings, is stationary, troublesome brush and slip ring construction is eliminated. When energized, the entire assembly consisting of pressure plate, inner and outer discs, and buttress plate is locked together by the magnetic force passing through it. When de-energized, Maxitorq separator springs instantly separate the discs creating air gaps which help to break up residual magnetism. Compactness, fast response, and flexibility of control make the #9000 Series clutch or brake ideally suited for a wide range of applications.




Write, phone, or wire Dept. MD now for Bulletin 90 describing the most advanced design of electric clutches or brakes available today.




THE CARLYLE JOHNSON MACHINE CO. • MANCHESTER, CONN.



Roll clutch cam section of automatic screw machine. Six inserts of Kennametal Grade K92 are used at point of great impact.

## In roll clutch cam section . . .

# KENNAMETAL* Grade K92 inserts outlast steel 8 to 1

Carburized and case-hardened *steel* inserts used at a point of great impact on an automatic screw machine were averaging 3.5 months' service. Replacing the inserts was a 4-to-5 hour job for the machine user.

Then, 29 months ago, the manufacturer installed a set of *Kennametal* tungsten carbide inserts on a machine as a test. The first set installed is still going strong, and has eliminated more than 30 hours' downtime.

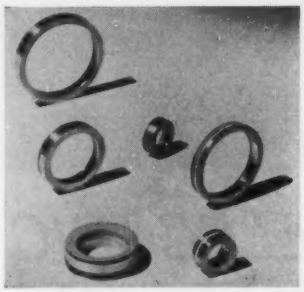
Recognizing how much customers would welcome this outstanding decrease in maintenance, this customer now uses Kennametal inserts as original equipment and replacement service parts for this model. In addition, plans have been made to extend the use of Kennametal for wear parts on other machines they manufacture.

The Kennametal family of hard carbide compositions contains many different grades. In this application, Kennametal Grade K92 was selected for its medium hardness (87.5 RA) and high transverse rupture strength (385,000 psi). Chances are K92, or one of the other Kennametal Grades, can solve one of *your* machine design problems. Why not find out more about this metal that has remarkable resistance to impact, abrasion, corrosion, extreme temperatures and pressures. Contact your Kennametal Representative or write us direct for Bulletin B-111-B, "Properties of Kennametal," and Bulletin B-666, "Proven Uses of Kennametal and Kentanium."* KENNAMETAL INC., Department MD, Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum. Kentanium is the registered trademark for one of the series that has special advantages for applications requiring a lighter weight material, or maximum resistance to temperature extremes. 33520

INDUSTRY AND KENNAMETAL ...Partners in Progress





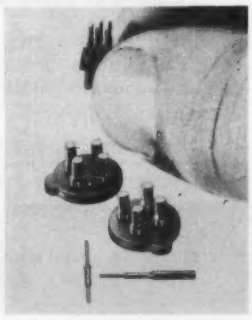
sets up a load toward the shaft, its polymer gasket deforming under constant pressure to produce a gas-tight seal. Polymer deformation is always toward the shaft and is self-adjusting to creep and wear. **Del Mfg. Div., Arrowhead-Puritas Waters Inc.**, 1005 S. Central Ave., Los Angeles 21, Calif.

*Circle 745 on Page 19*

### *Miniature Sockets*

**retain holding power through many insertions**

Lead wires as small as 0.004-in. diam are accepted and held securely in miniature sockets. Sockets are mounted in printed-circuit boards by staking or dip soldering, eliminating hand-soldering operations and completely precluding heat damage to semiconductor components. Accommodating diodes, transistors, subminiature vacuum tubes, capacitors, and resistors, sockets retain holding power throughout many insertions and withdrawals. Flexibility in installing miniature plug-in components is greatly increased. Sockets accept 0.010 to 0.060 in. diam as standard, and down to 0.004 in. on special order. Designated Tran-Grip, socket embodies a new design in a closed-entry, multiple-spring, contact-gripping device. Units are supplied as individual sockets, or two or more

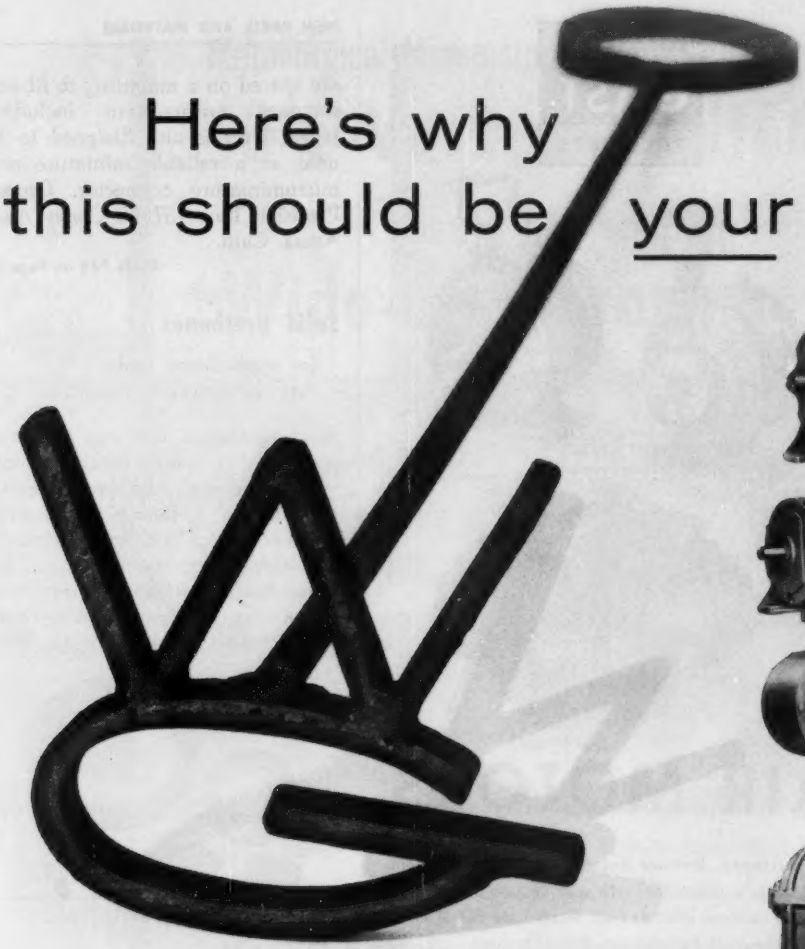


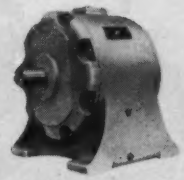


*Circle 530 on Page 19*

*Circle 531 on Page 19→*

# Here's why this should be your brand

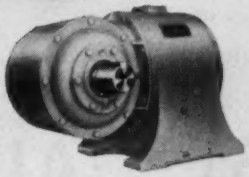




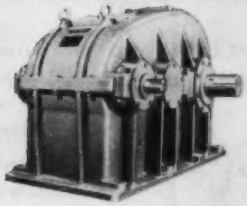
StraitLine
Speed Reducer



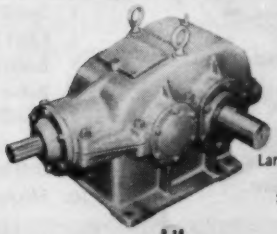
Shovel Base
Horizontal
Gearmotor



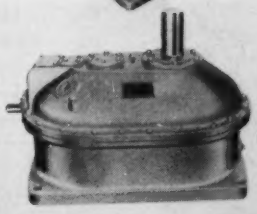
Right Angle
Speed Reducer



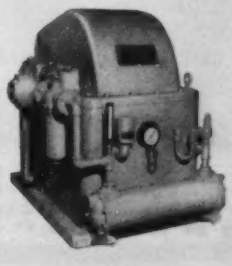
Parallel Shaft
Speed Reducer



Large Right Angle
Horizontal
Speed Reducer



Large Right Angle
Vertical
Speed Reducer



Small High
Speed Unit

*because... on the long run...*

## QUALITY COSTS YOU LESS!

You can't always see quality... many times a second rate piece of machinery can look good. It's on the long run that quality shows up and actually saves you money.

Industry has proved **Western Gear** power transmission drives for 72 years. And Western Gear has cooperated with industry by consistently designing into its drives the features their customers want.

Take reliability, a critical requirement in any power transmission installation: precise gear cutting and finishing techniques and careful heat treatment to uniform hardnesses are unequalled in **Western Gear's** finished drives. This means long life, quiet operation, minimum maintenance and reliable full load performance for you year after year.

Next time you need gear drives for any power transmission application, check the brand that's designed and built to your needs and to your long run requirements... **Western Gear.**

For free catalogs, write to **WESTERN GEAR CORPORATION,** Industrial Products Division, P.O. Box 126, Belmont, California.

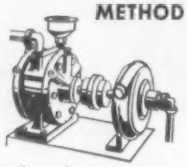
W INDUSTRIAL PRODUCTS DIVISION



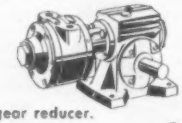

Six sizes . . .
all variable-speed
explosion-proof

# GAST rotary vane AIR MOTORS

**CHOOSE YOUR DRIVE METHOD**



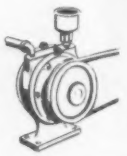
Direct through flexible coupling.



Use gear reducer.



Flange mounted – vertical operation.



Driving pulley.

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
2. Low initial cost compared to other motors.
3. Speed variable with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on some models.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly light, compact for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

| Model No. | 1AM | 2AM | 4AM | 6AM | 8AM | 16AM |
|---|---|---|---|---|---|---|
| H.P. at 90 P.S.I., 2000 RPM | 0.13 | 0.57 | 1.1 | 2.0 | 4.0 | 7.0 |
| Weight, lbs. | 1½ | 5½ | 8 | 17 | 25 | 65 |

*For complete performance data, write for Air Motor Bulletins. Specify models that interest you.*

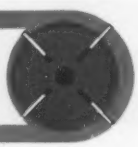
**GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan**

**SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG**

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

*"Air may be your answer!"*



**Circle 532 on Page 19**




are spaced on a mounting to fit any standard arrangement including Jedec. Unit is also designed to be used as a reliable miniature and microminiature connector. **Omega Precision Inc.**, 757 N. Coney Ave., Azusa, Calif.

**Circle 746 on Page 19**

## Solid Urethanes

**for applications under extreme operating conditions**

Solid urethanes that can be compounded to specifications in roll, sheet, tube, rod, and cast parts are available for a variety of industrial applications. High tensile strength and abrasion resistance can be combined with elasticity and resilience in varying degrees to satisfy individuals needs. Urethanes also combine superior hardness, rigidity, load carrying, oil resistance, and oxygen and ozone-resistance properties. Versatile material replaces metal, ceramics, rubber, and other materials in applications under extreme operating conditions, such as vibration pads, diaphragms, gaskets, and belts. Urethane provides excellent shock absorption and vibration damping. **Industrial Div., Armstrong Cork Co.**, Lancaster, Pa.



**Circle 747 on Page 19**

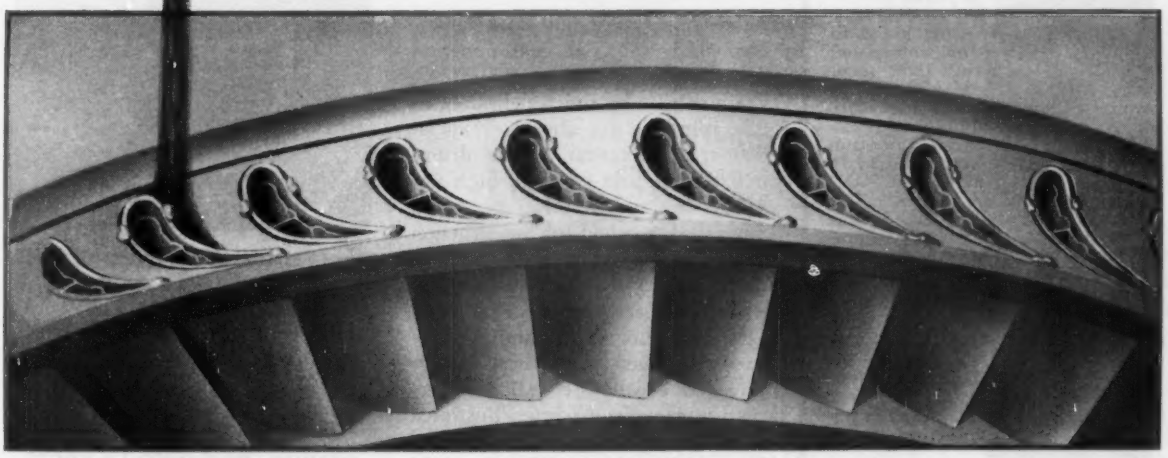
## Instrument Counter

**has 0.1 oz-in. maximum torque at room temperature**

Developed for aircraft-instrument applications, miniature counter maintains a low friction torque over full environmental range. Constructed entirely of precision machined parts, counter can be mounted using a bracket, as illustrated, and driven by means of a through shaft from either side. Maximum torque is 0.1 oz-in. at

Metallurgical Memo from General Electric

# G-E Vacuum-Melted Alloys Now Conquer Wide-Gap Brazing Barriers



Wide-gap brazing alloy is applied to turbine nozzle assembly. Vanes are tack-welded in position prior to brazing.

## New G-E Wide-Gap Brazing Alloys offer:

- New brazing techniques
- Bridging of joint clearance up to .060 in.
- Faster, more simplified job fabrication
- Extreme cleanliness provided by induction vacuum melting
- Improved erosion characteristics
- Solution to many problems of distortion and stress relieving associated with fabrication by welding
- Lower manufacturing cost

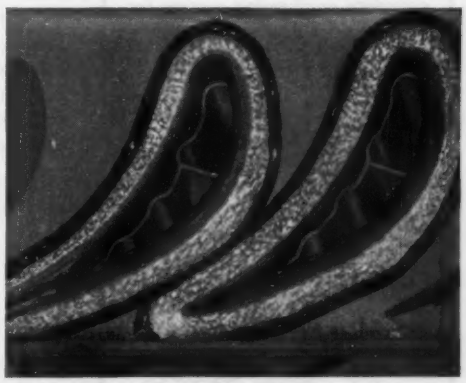
**Looking for new methods** of fabricating high-temperature metals? Nothing can equal G-E vacuum-melted brazing alloy powders for critical applications. All provide the ultimate in exacting chemical control and extreme cleanliness which air-melted alloys cannot match.

Now this latest G-E brazing "breakthrough" of wide-gap alloys extends the use of brazing to a new, wider scope of joining applications.

Get all the facts about G-E vacuum-melted brazing alloys as a short-cut to lower cost manufacturing methods. Write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Blvd., Detroit 32, Michigan.*

METALLURGICAL PRODUCTS DEPARTMENT

GENERAL ELECTRIC



Insert shows vanes completely brazed in spite of gaps. Stains around perimeter of brazes are from stopoffs.

CARBOLOY® CEMENTED CARBIDES • MAN-MADE DIAMONDS • MAGNETIC MATERIALS • THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS

COMPLETE
MAGNETIC DISC
BRAKE LINE
offered by
DINGS

MOTOR MOUNTING



A brake for every need! Direct-acting standard and waterproof, dust-tight models with torque range of 1½ to 175 lbs. ft. Hazardous-location types in 3 to 75 lbs. ft. "C" flange mountings. "Thru-Shaft", vertical and other special designs available.

FOOT MOUNTING



All Dings Brakes available with foot mounting bracket for installation wherever a "C" flange mounting is impractical.

SERRATED CLUTCH COUPLING



Two styles available: Magnetically-engaged, spring-released —1200 through 32,000 lbs. ft. torque, and spring-engaged, magnetically-released—2000 through 16,000 lbs. ft. torque.

DINGS SERVICE

Dings representatives in 29 U.S. cities, 3 Canadian cities, and in foreign countries, offer expert assistance with your brake or clutch problems, and prompt repair parts service. Ask about Dings complete engineering service for your brake or clutch application.

Send for FREE BULLETIN

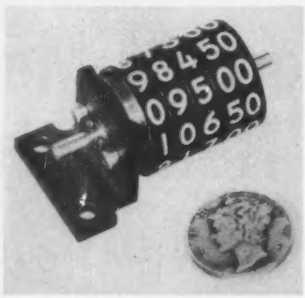


Bulletin BK-4106 gives general information about Dings complete line of Magnetic Brakes. Includes applications, data, mounting, enclosures, selection, and useful engineering information. Send for your copy today.

DINGS BRAKES, Inc.

A subsidiary of Dings Magnetic Separator Co.
4714 West Electric Avenue
Milwaukee 48, Wisconsin

Circle 534 on Page 19



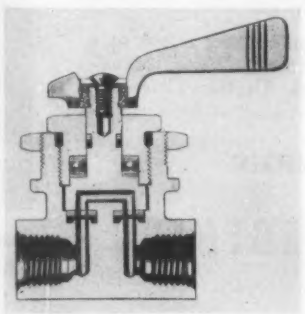

room temperature, and does not exceed 0.25 oz-in. at environmental extremes of −55 to +100 C. Counter can be run indefinitely at 350 rpm and for short periods at 600 rpm. Diameter of the drums is 0.672 in., and 0.187-in. high numerals are spaced 0.150 in. apart. Simplified method of construction facilitates the use of up to five rotating drums while maintaining desired torque and numeral alignment. One, two, four or five transfers between the first two drums can be provided to allow counting in desired increments. Counter illustrated counts in increments of 50. Melland Gear & Instrument Co. Inc., 88-06 Van Wyck Expressway, Jamaica 18, N. Y.

Circle 748 on Page 19

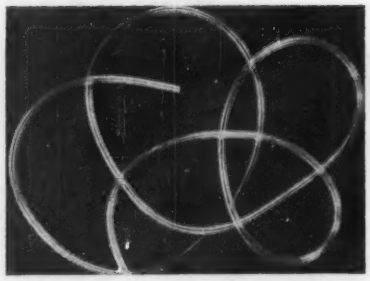
## *Selector Valve*

**miniature unit has wear-compensating seals**

Miniature 3000-psi selector valve for directional flow has micro-finish sliding seals. The 2 x 2-in. valve, Mini-Lo-torq, is suitable for both pneumatic and hydraulic services. Seals are wear-compensating, wiping the surfaces clean as they move across the ports. Handle turning is easy, even at maximum pressure. Maximum panel thickness is 5/16 in. Body is forged aluminum alloy, with internal parts of stainless steel.



MUNRAY
ENGINEERED PLASTICS FOR INDUSTRY



**For standards from stock or custom products designed to your needs, you can depend on Munray! . . . backed by laboratory facilities, on-site technical service, and over 15 years plastics experience!**

Check these specialized tubings available from stock

**AIR HOSE** non-collapsing under vacuum especially resistant to abrasion, resists oils and greases, four stock sizes rated 125 psi.

**CYCLON 310** crystal clear for visual inspection, resists most corrosives at temperatures from 0°—175°F, thirty-seven sizes including 6 wall thicknesses.

**CYCLON 470B** approved by U.S.D.A. for beverages, milk and fatty acids. 470-F formulated for other food processing applications.

**CYCLON 136** designed especially to handle gasolines and similar aromatic hydrocarbons.

**MUNRAY POLYETHYLENE** — recommended for low pressure, low-cost applications such as instrument tubing, colored for coding, takes standard fittings.

**MUNRAY NYLON** accepts 1,000 and 2,000 psi operating pressures.

TEST LENGTH AVAILABLE!
STATE YOUR APPLICATION DIRECT TO

MUNRAY
PRODUCTS, DIVISION TEXTRON INC.
SPECIALISTS IN ENGINEERED PLASTICS
12406 Crossburn Avenue Cleveland 35, Ohio
Distributors in All Major Cities

Circle 535 on Page 19



## High Capacity

# PORTABLE BRONZE VALVES

## Cut Your Valve Costs

Consolidated Portable Bronze Safety Valves are designed specifically for package type steam generators and fire tube boilers. They enable you to design this type of equipment more economically.

High capacity is designed into each valve. Where a valve of lower capacity is adequate, medium capacity valves *of the same size* can be used with the assurance that the valves will always conform to actual requirements. Both initial costs and maintenance costs are held to a minimum.

You are sure of stable performance and uniform blowdown control in Consolidated Portable Bronze Safety Valves. Opening is sharp and clean, without simmer. The seat is machine lapped optically flat to assure positive tightness.

Design for savings from the start. Choose Consolidated Portable Bronze Safety Valves. Be certain of fine operation and long service life, free of costly maintenance. Complete specification data are available in Bulletin 740. Write for a copy.



*Consolidated Safety Valve Type 1540 Series. Sizes: ½" through 2½". Pressures to 250 psi. Temperatures to 406° F. Available with side or top outlet, medium or high capacity.*

MANNING, MAXWELL & MOORE, INC.
East Main Street
Stratford, Connecticut

*Send me your Bulletin 740 which tells all about Consolidated Portable Bronze Safety Valves.*

Name_____

Title_____

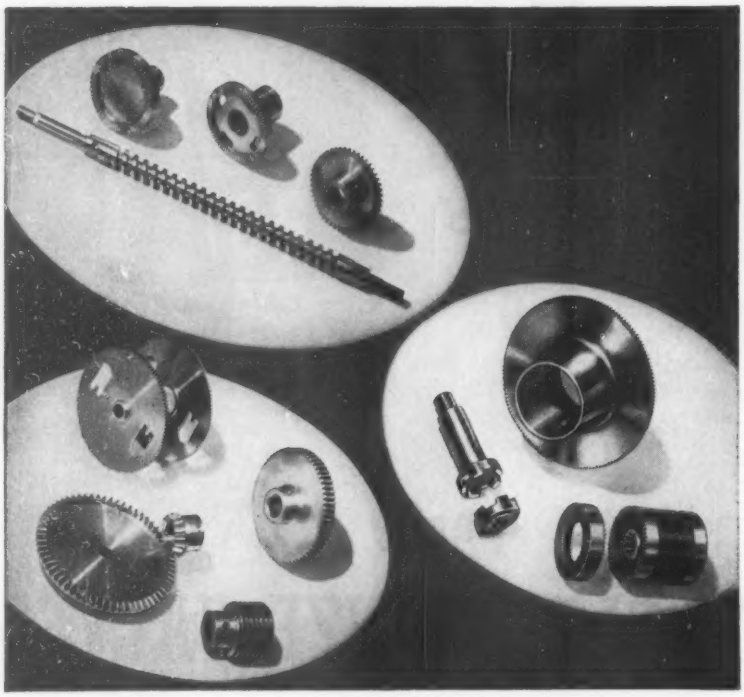
Company_____

Address_____

City/Zone_____ State_____

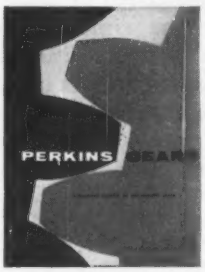
**CONSOLIDATED SAFETY VALVES**
*A product of*
**MANNING, MAXWELL & MOORE, INC.**

*Valve Division • Stratford, Connecticut • In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*



# small and fine pitch gears for precision equipment

No matter how fine your gear requirements — Perkins can solve your problems. Perkins unique custom-gear engineering service, available to your engineering staff prior to the blueprint stage, will . . . eliminate production headaches . . . cut excessive costs. This service — recognized by leaders in the radar, electronic and missile fields, and backed by 52 years of custom gear experience — assures the precision quality needed to guarantee trouble-free operation. Don't gamble with gear performance . . . Perkins skilled personnel, together with modern up-to-date equipment guarantees fast delivery on prototypes or production runs. Call or write Perkins for complete information on custom-gear engineering and a quotation on your requirements. Then judge for yourself.




**YOURS ON REQUEST** Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

**PERKINS**
**MACHINE AND GEAR CO.**

Dept. 73 West Springfield, Mass.
Telephone: REpublic 7-4751



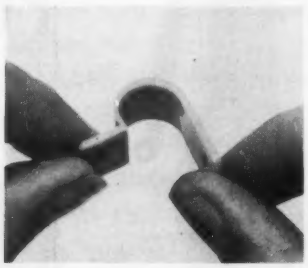
Valve is available in two, three, and four-way, in sizes 1/8 and 1/4 in. internal straight-thread gasket seal (AND10050), and with internal pipe-thread connections. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 35, Ohio.

*Circle 749 on Page 19*

## Plastic Clamps

**have high tensile strength and rigidity**

Loop-type polypropylene plastic clamps are low in cost, and are exceptionally tough. They have high tensile strength and rigidity, and excellent dielectric properties, even at high frequencies. Clamps resist solvents, grease, oil, many common



acids, and chemicals. They are available in seven sizes from 1/8 to 1/2 in. diam, and are molded to assure uniform size and shape. All edges are round and smooth to give full protection against vibration, strain, and pulling. **Holub Industries Inc.**, 430 Elm St., Sycamore, Ill.

*Circle 750 on Page 19*

## Circuit Breaker

**subminiature unit is shock and vibration resistant**

Hydraulic-magnetic circuit breaker, Series VP, weighs only 1 1/2 oz. Breaker incorporates shock and vibration-resistant features that make it suitable for use in airborne, portable, and mobile equipment. Unit requires a single mounting hole, and is able to double as an on-off power switch. A single-pole breaker unit is available for operation at 100 v, 60 or 400 cycles ac, or at 50 v dc, in any current rating from 0.05 through 15 amp. Fully magnetic actuation enables breaker to provide temperature-stable performance



*Circle 537 on Page 19*

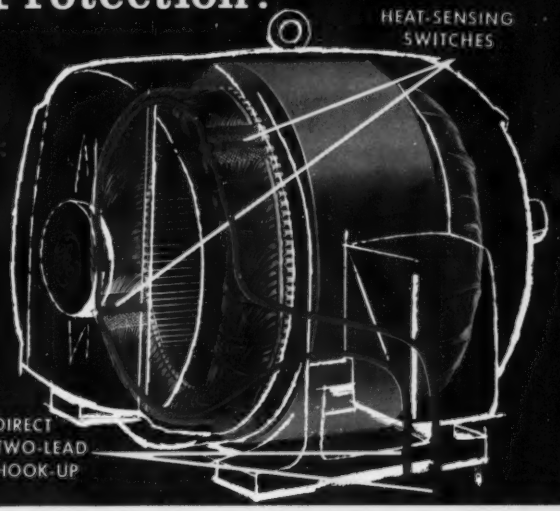
GENERAL ELECTRIC

# New Concept in Motor Protection!

# Tri-Clad '55' Thermo-Tector*

## SYSTEM ENDS OVERLOAD BURNOUT!

*Trade-mark of General Electric Co.




General Electric offers a *totally new* type of protection on *all* Tri-Clad '55' motors 7½-125 hp!

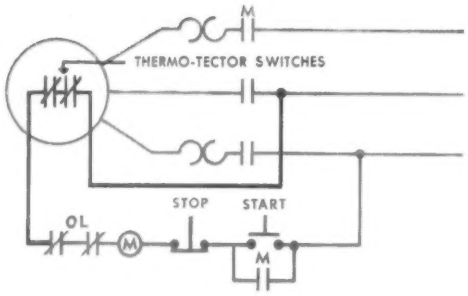
Exclusive **THERMO-TECTOR** system has heat-sensing switches buried in stator windings. Switches shut off motor *only* when stalls, overloads or other conditions threaten heat damage to motor windings.

Unique **THERMO-TECTOR** system "anticipation" feature varies motor shut-off point according to rate of winding heat rise. This flexibility allows *maximum motor output* under all conditions.

TURN PAGE FOR FURTHER INFORMATION

# NEW Tri-Clad® '55' THERMO-TECTOR SYSTEM

## Allows Full Motor Output— No Wasteful "Safety Margin" Needed




Thermo-Tector system needs *no costly amplifying relays*, connects directly to any G-E motor controller.

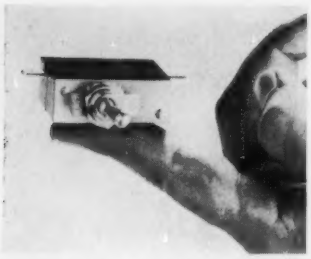
You get full output from Tri-Clad '55' motors with Thermo-Tector system. Variable response feature of heat-sensing switches allows motor to operate right up to safe limits under any operating condition.

Thermo-Tector switches are offered on *all* Tri-Clad '55' motors in frames 254U-445U. For more information, contact your G-E Apparatus Sales Office or write for Bulletin GEA-7092, Section 866-03, Schenectady 5, N. Y.

SMALL AC MOTOR & GENERATOR DEPARTMENT

GENERAL ELECTRIC

*Circle 538 on Page 19*



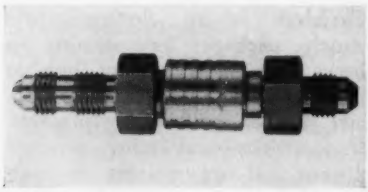
that makes derating unnecessary. Three different overload responses permit the breaker to be matched to the load characteristics of the application. **Heinemann Electric Co.**, 376 Magnetic Drive, Trenton 2, N. J.

*Circle 751 on Page 19*

### *Miniature Connector*

**for electronic cooling applications**

Series 20 miniature fluid connector is available in size ¼ in. with ¼-in. ends, and features an automatic push-pull device for quick connect-disconnect operation. Weighing exactly 1 oz, unit withstands pressures to 5000 psi and temperatures from −20 to +400 F. It is normally made of aluminum with Viton-A seals, although stainless steel and



various elastomers are also available. Component parts are interchangeable. **E. B. Wiggins Oil Tool Co. Inc.**, 3424 E. Olympic Blvd., Los Angeles 23, Calif.

*Circle 752 on Page 19*

### *Instrument Ball Bearings*

**have lightweight, stainless-steel retainer**

High-precision, low-torque retainer is featured in a new series of 48 instrument ball bearings. Made in industry-standard R2, R3 and R4 sizes, bearings have a lightweight, stainless-steel retainer that reduces internal friction to a minimum. Two sections of the retainer are crimped together with a pre-

**FRICTION-FREE MOTION:** Recirculating way bearings and ball screws provide mechanical advantages for supporting and moving machine components. TYCHOWAY bearing combines rigidity and capacity of rollers with compact, easy-to-install recirculating feature. Eliminates stick-slip as low coefficient of friction—less than .005—equalizes starting and moving friction. 25 lb force smoothly moves 5,000-lb load even at low speed. Center guide flange assures accurate roller alignment. Antifriction characteristics minimize lubrication problems. SUPER-CISION ball screw combines advantages of screw and nut with antifriction characteristics—mechanical efficiency of 90% or more. Clean, compact nut is result of patented internal ball return. Twin-nuts' unique vernier adjustment (see cut) permits precise preload setting, eliminates backlash. Ball screws and nut housings made to any configuration to suit requirements. These companion products make linear motion completely predictable and accurate, with minimum effort.



Write for Bulletin 22-50



Write for Bulletin 25-50

Special Products Division
**Scully-Jones and Company**
1905 South Rockwell Street, Chicago 8, Illinois

SCULLY JONES

*Circle 539 on Page 19*




Toroids that generate lower heat and higher efficiencies and provide more uniform performance are another advancement made possible by ultra-thin magnetic alloy strip from Precision Metals. This unique material—now available in production quantities—can be supplied in virtually any of the high magnetic permeability alloys such as 4-79 Moly Permalloy, 50-50 grain-oriented nickel iron and Muvar®.

Precision Metals strip and foil is cold rolled in thicknesses from .010″ to .0001″ and can be furnished slit to tightest dimensional tolerances. Note these other important advantages:

**uniform magnetic properties** **extremely close tolerances**
**dimensional uniformity** **excellent surface characteristics**

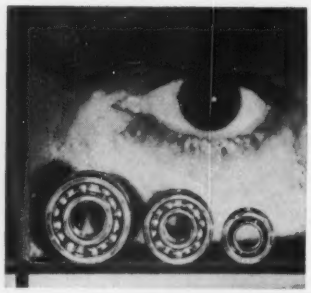
To meet specific requirements, Precision Metals can furnish custom alloys to your specification in the form you need. Write today for fully illustrated facilities booklet **MD-9.**




HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

Regional Representatives: COREY STEEL COMPANY • Chicago, Illinois
FAGERSTA STEELS PACIFIC, INC. • Los Angeles, California



determined degree of looseness so that the two sections move slightly relative to each other, greatly reducing starting torque. Bearings are available for a broad range of precision applications including servos, generators, small motors, synchros, and gyros. Made to tolerances of ABEC Class 7, R-Series bearings are available with flanged outer rings for simplified mounting, with single or double shields, and as either duplexed or preloaded pairs. ODs range from 0.375 to 0.625 in., with bores from 0.125 to 0.250-in. **Miniature Precision Bearings Inc.,** Keene, N. H.

*Circle 753 on Page 19*

## *Clutch-Hub Assembly*

**is ready to install**

Cyclehub is an electromagnetic clutch package incorporating a bearing-supported adapter hub to facilitate mounting choice of special sheaves, pulleys, or sprockets. Concentricity and other accurate dimensional requirements are built in. Unit can be employed as either the driving or the driven member. Open model is available for either stub or through-shaft mounting, while optional shrouded model, providing integrally mounted brush-holder boxes and protective guard for the rotating clutch parts, is supplied for stab-shaft installations



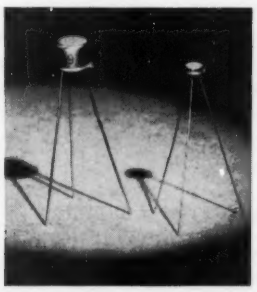
only. Power-supply control units are available as a circuitry package to provide required 1/3-amp dc voltage plus potentiometer selection of acceleration rates. Sizes range from ½ to 20 hp with a wide selection of standard bore sizes. **Cycledynamics Inc.**, 19025 W. Davison Ave., Detroit 23, Mich.

*Circle 754 on Page 19*

## *Miniature Transistor*

**has guaranteed welded hermetic seal**

Microbloc RT697M is a high-powered, improved 2N697 transistor in a solid-design, microminiature package. A silicon mesa transistor (right) with a guaranteed welded



hermetic seal, it occupies about 1/7th the volume of the standard 2N697 (left), is 0.063 in. flat, 0.211 in. in diam, and weighs only ¼ gram. Unit has 3 w power dissipation, 50 per cent more than the standard 2N697. Transistor is a silicon crystal imbedded in a gastight, hermetically sealed, welded block that is essentially all heat sink. Unit withstands a minimum of 1500 g shock and 20,000 g acceleration. It is designed for installation in conventional circuit boards and in or on rigid or flexible circuit substrates, including wafers and various materials used in high-density designs. **Rheem Semiconductor Corp.**, 350 Ellis St., Mountain View, Calif.

*Circle 755 on Page 19*

## *Mass Transducer*

**measures liquids or gases**

Series 3000 fluid-driven mass Pottermeter measures liquids or gases in absolute mass units and provides repeatable accuracies to ±¼ per cent of reading with linear response over a 10:1 range. It is compact, self-





*Circle 541 on Page 19*




TRANSFER MACHINE BUILT BY BUHR MACHINE TOOL CO., ANN ARBOR, MICHIGAN

# Automated GIANTS like this

REQUIRE STRONG HYDRAULIC *HEARTS* EVERY MINUTE OF THEIR WORKING LIFE

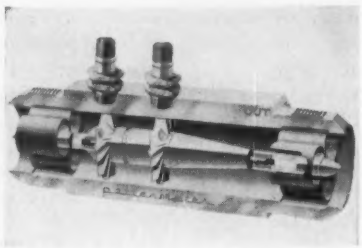
The precisioned flow control of RACINE PUMPS assures the split-second timing and efficiency required to operate this complex Buhr Transfer Machine . . . custom-built for the completely automatic machining of 120 auto-cylinder heads hourly for a leading automotive manufacturer. Compact RACINE VALVES control feeds and reverse movements on all 323 operations performed by the machine. RACINE 4-WAY SOLENOIDS help one man operate this mechanical giant. Buhr has used RACINE PUMPS and Reservoir Units on custom-built machines for the automotive industry for over 10 years.

**24 RACINE PUMPS**
*operate this 58 station 500-ton transfer machine*

RACINE

**Racine Hydraulics & Machinery, Inc.**
RACINE, WISCONSIN
HYDRAULICS DIVISION



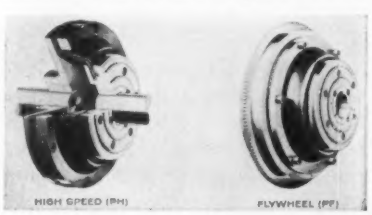
contained, and requires no external power source or intermediate specific gravity correction. Unit is rugged, lightweight, and operates in any position. It tolerates a wide range of viscosities, corrosive and nonlubricating fluids, and a broad temperature range from −430 to +850 F. By measuring elapsed time taken for the phase-angle displacement to traverse a reference point, a direct measure of mass-flow rate is effected and can be observed or recorded on any laboratory-type counter or oscilloscope. **Potter Aeronautical Corp.**, Union, N. J.

*Circle 756 on Page 19*

## Cushion-Type Couplings

**incorporate pan-shaped rubber flexing element**

Para-flex High Speed and Flywheel cushion-type couplings accommodate, either singly or in any combination, angular and parallel shaft misalignment and end float, absorb torsional vibration, and cushion shock loads. Pan-shaped rubber flexing element permits operation at higher speeds and transmission of greater torque than with previous units. High Speed coupling, for speeds to 5230 rpm, consists of the flexible member supported on one side by a clamp-ring flange, and with its larger side bolted to a steel disc. Flange and disc are equipped with Taper-Lock bushings for quick, easy mounting on shafts. Flywheel coupling is like the High Speed unit except that its larger side bolts directly to the flywheel of an internal-combustion engine. It is






*Circle 542 on Page 19*

available in sizes to fit the bolt circles of most standard SAE flywheels to 19¼ in. diam. Couplings require no lubrication. They are furnished in sizes to deliver up to 47 hp per 100 rpm, and with Taper-Lock bushings to fit shafts to 4 in. diam. **Dodge Mfg. Corp.**, Mishawaka, Ind.

*Circle 757 on Page 19*

## *Small-Flow Valve*

**controls ultrasmall amounts of liquid or gas**



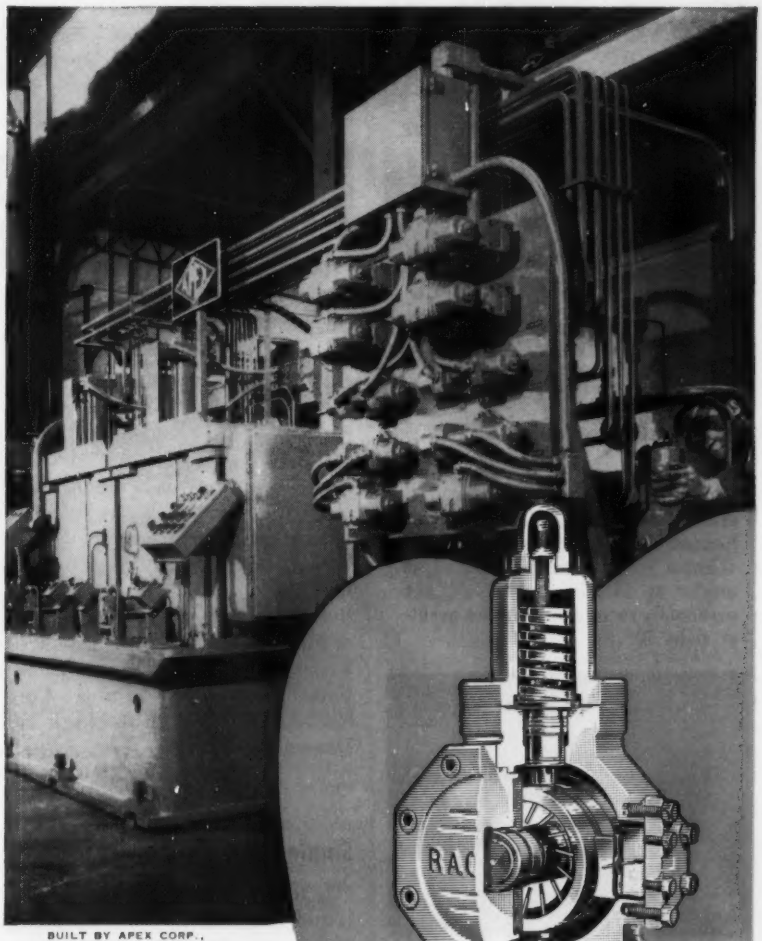
With the Micro-Flow valve, a flow coefficient of as low as 0.003 to zero can be controlled linearly over a stem travel of ⅝ in. At 5000 psi the valve can be throttled from 3 cc per min to 5 gpm, and at lower pressures valves can be used to deliver as little as 10 drops per hr. Pressure ratings are to 10,000 psi. Clog resistance and vibration resistance are obtained by restricting all flow to a variable triangle-shaped orifice. Standard materials are carbon steel, stainless steel, or bronze. Flow seals are Teflon, synthetic rubber, or stainless steel. Valve in the Full-View style gives visible orifice indication. Air diaphragm-actuated valves are available for 3-15 psi signal or 125 psi factory air. **General-American Valve Co.**, P. O. Box 444, Corona del Mar, Calif.

*Circle 758 on Page 19*

## *Pushbutton Switches*

**in illuminated and nonilluminated types**

New pushbutton switches in illuminated and nonilluminated types are small, flexible multiple-pushbutton units. Model 20 illuminated switch (shown) has a printed-circuit lamp

BUILT BY APEX CORP., ROSEVILLE, MICHIGAN

# This active hydraulic heart helps

*the HEART of this impregnating machine is a* RACINE MODEL 6FA PUMP

SEAL POROSITY IN 106 TRANSMISSION CASES EVERY HOUR

A RACINE VARIABLE VOLUME PUMP and 10 RACINE VALVES control *all* mechanical operations in this Apex impregnating machine, which seals leaky transmission cases at a major auto firm's transmission plant in Toledo, Ohio. Apex specified RACINE equipment because its design simplifies machine design problems . . . eliminates the need for extra pumps and valves. RACINE PUMPS are easy-to-control . . . handle pressure compensation *automatically* for varying gpm requirements. Apex has *preferred* RACINE for over 10 years!

RACINE

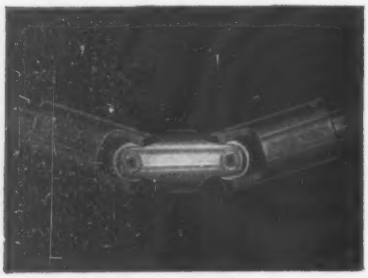
**Racine Hydraulics & Machinery, Inc.**
RACINE, WISCONSIN
HYDRAULICS DIVISION

*Circle 543 on Page 19*

# How Curtis helped a design engineer "BEAT THE HEAT"



This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

**CURTIS UNIVERSAL JOINTS**

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

**14 SIZES ALWAYS IN STOCK —**
3/8" to 4" O.D. (6" joints on special order)

***Not sold through distributors. Write direct for free engineering data and price list.***

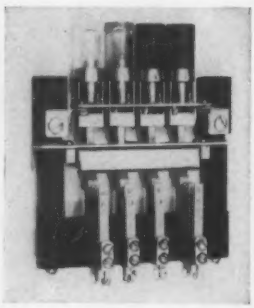
TRADE MARK **CURTIS**

**UNIVERSAL JOINT CO., INC.**
**52 Birnie Avenue, Springfield, Mass.**
*As near to you as your telephone*

**EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919**

*Circle 544 on Page 19*



strip with front-of-panel replacement of lamps (no extractors needed). Maximum depth behind panel is 3 11/16 in. for Model 20 and 2⅝ in. for unilluminated Model 10. Both models are available with from 2 to 16 buttons per row, with momentary, locking, or accumulative lock button actions. Positive lock-out mechanism is also available to prevent more than one button from being depressed at a time. **Switching Controls Corp.**, 8222 Lankershim Blvd., North Hollywood, Calif.

*Circle 759 on Page 19*

## *Single-Phase Motor*

**is totally enclosed and fan cooled**

Single-phase motor with capacities from 1 to 5 hp is totally enclosed and fan cooled. Internal fans, cast integrally with the rotor, recirculate internal air and eliminate hot spots. Large external fan, protected by a hood, blasts air over the heat-dissipating fins which are cast integrally with the frame. No dust or moisture can enter the motor. Condensate inside the motor can be bled off by means of two plugged openings. External centrifugal switch has been mounted on the outside of the motor for accessibility, and a protective cap is readily removed for access. Same switch fits






**NEW SERIES of Antenna SLIP RING Assemblies**

# 12 to 500 RINGS

A standardized line of large Slip Ring assemblies, designed for a multiplicity of instrumentation, control and power circuit applications. First production assemblies are in use on radio telescopes, radar and tracking antennas and human centrifuge installations.

Assemblies vary from 12" to 72" in length, are either shaft or flange ball-bearing mounted and may be specified with hermetically sealed housings. Noise levels are held to a minimum. So are intercircuit losses, cross-talk and radiation, through proper shielding.

*For complete information, write:*

**SLIP RING COMPANY of AMERICA**
3612 West Jefferson Blvd., Los Angeles 16, Calif.

*Circle 545 on Page 19*

# Copper Alloy Bulletin

BRIDGEPORT BRASS COMPANY

# new BRIDGEPORT NIRONZE® 635 gives 90,000 psi yield strength

**90,000 psi Yield Strength Obtained with New Age-Hardenable Copper-Nickel-Silicon Alloy**

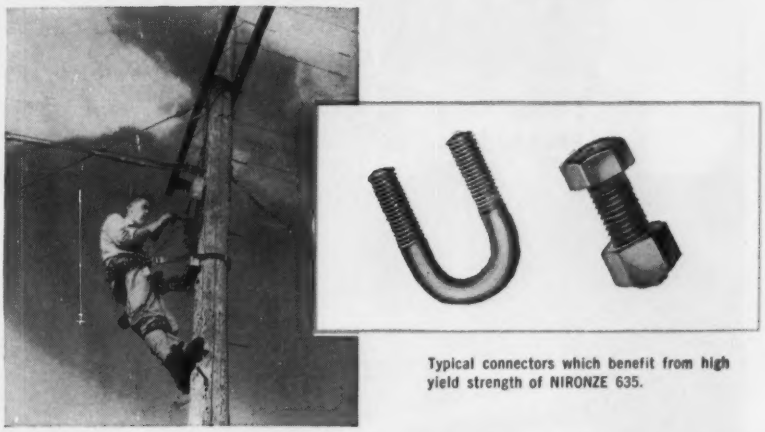
Bridgeport Nironze 635, an age-hardenable copper-nickel-silicon alloy, combines excellent cold-working properties with high tensile and very high yield strengths, good electrical conductivity, excellent general and stress-corrosion resistance. Supplied in the solution-treated and drawn condition, Nironze 635 offers exceptional cold-working properties. A low-temperature heat treatment, following additional cold-work age, hardens this alloy to produce tensile strengths of 100,000 psi, yield strengths of 85,000 psi and improved electrical conductivity of a minimum of 35% IACS.

**Easily Cold-Formed... Machined**

The excellent cold-working properties of Nironze 635 in the *solution-treated and drawn* condition allow such severe cold work as upsetting, cold-heading, roll-threading, bending, forming or similar operations to be carried out with ease. Heat treatment following this cold-work age-hardens this alloy to produce maximum tensile and yield strengths.

Nironze 635 in the *solution-treated-drawn-aged* condition has a machinability about 30% of free-cutting brass rod, thereby making it possible to carry out such conventional machining operations as sawing, grinding, turning, milling or similar operations.

Maximum cold-work may be performed on Nironze 635 in the *solution-treated* or soft condition. In order to obtain highest possible physical properties, this alloy must be cold-worked from 50-80% before aging.



Typical connectors which benefit from high yield strength of NIRONZE 635.

**Proved by Performance in These Applications**

Cold-headed bolts and fasteners used in pole line hardware, switch gear, wire connectors, neon signs, railway equipment, exposed electrical parts and structural supports, marine hardware and fittings can all use Nironze 635 to advantage. The new alloy's unique combination of high yield and tensile strengths, good conductivity and high corrosion resistance provides design and production advantages never before offered by a silicon bronze.

**Test a Sample Now**

Nironze 635 has been thoroughly evaluated in the laboratory and in the field to insure the high quality and top performance common to all Bridgeport alloys. To get your test samples and full technical information, call your nearest Bridgeport Sales Office. Or write us direct. Dept. 8909.

Nironze 635 is presently available as rod or wire, supplied in the solution-treated, solution-treated and drawn, and solution-treated, drawn and aged.

## NIRONZE PHYSICAL PROPERTIES

| | |
|---|---|
| Density | 0.320 lb/in.³ |
| Color Red | similar to copper |
| Thermal Expansion | 8.9 x 10⁻⁶/°F |
| Melting Point | 1990°F |
| Nominal Composition: | |
| Copper | 97.5% |
| Nickel | 1.9% |
| Silicon | 0.6% |
| Total | 100.0% |
| Electrical Conductivity, % IACS | |
| Cold-drawn and aged | 30% |
| Cold-drawn | 15% |

**MECHANICAL PROPERTIES (Nominal)**

| Form | Condition | Tensile Strength psi | Yield Strength psi | Elongation % (4D) | Contraction of Area % | Rockwell B Hardness | 0/0 IACS |
|---|---|---|---|---|---|---|---|
| Rod and Wire | Solution-Treated | 40,000 | 12,000 | 50 | 90 | 7 | 24 |
| | Solution-Treated, Aged | 88,000 | 70,000 | 12 | 20 | 86 | 43 |
| | S.T. Drawn 50% | 65,000 | 62,000 | 18 | 87 | 67 | 22 |
| | S.T. Drawn 50%, Aged | 100,000 | 90,000 | 12 | 25 | 95 | 42 |
| | S.T. Drawn 80% | 70,000 | 65,000 | 15 | 85 | 73 | 22 |
| | S.T. Drawn 80%, Aged | 103,000 | 97,000 | 17 | 62 | 96 | 39 |

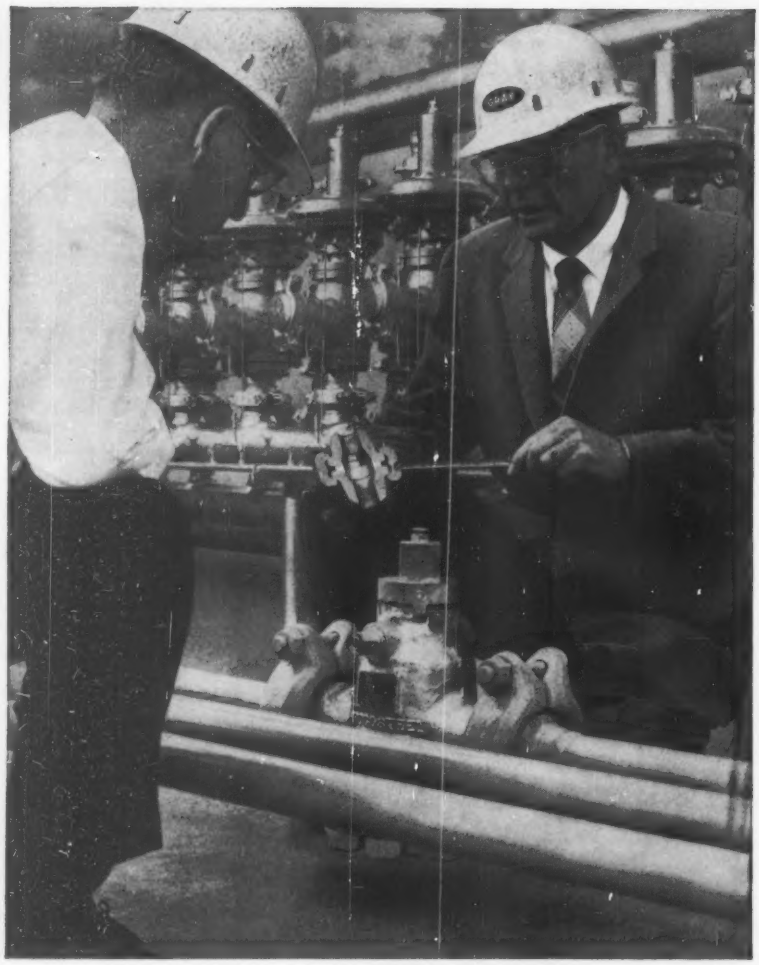
**COMPARATIVE RATINGS OF NIRONZE 635 vs STANDARD SILICON BRONZES**

| | Physical Properties | | | Fabrication Properties | | | Mechanical Properties | | |
|---|---|---|---|---|---|---|---|---|---|
| | Electrical Conductivity (Annealed) % IACS | Melting Point Liquidus °F | Density lb/in.³ | Cold Workability | Machinability Rating % | Annealing Temp. °F | Tensile Strength psi | Yield Strength psi | Rockwell B Hardness |
| NIRONZE 635 | *35 | 1990 | 0.320 | Excellent | *30 | **850-900 | 100,000 | 85,000 | 95 |
| High Silicon Bronze (A) | 7 | 1880 | 0.308 | Excellent | 30 | 900-1300 | 108,000 | 60,000 | 95 |
| Low Silicon Bronze (B) | 9 | 1940 | 0.316 | Excellent | 30 | 900-1250 | 90,000 | 67,000 | 90 |

*Drawn and aged **Aging temperature

©The term "Nironze" is a registered trade-mark of the Bridgeport Brass Company

BRIDGEPORT BRASS COMPANY
Bridgeport 2, Connecticut • Sales Offices in Principal Cities
*Specialists in Metals from Aluminum to Zirconium*



**GRAYLOC® Seal: Leak-proof at any pressure**

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAY GRAYLOC SALES DIVISION *Tool Company*

P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240 05



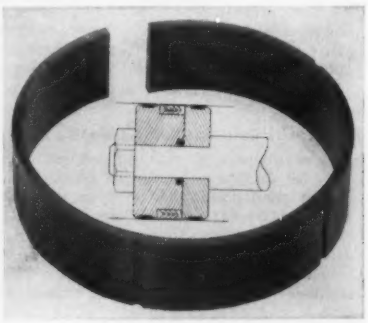
all sizes of motors. Switch positively disengages when motor has attained preset speed. **Brook Motor Corp.**, 3302 W. Peterson Ave., Chicago 45, Ill.

*Circle 760 on Page 19*

## *Piston Wear Rings*

**for heavy-duty use are filled nylon**

Filled nylon piston wear rings are available in a wide range of standard sizes from 2½ to 7½ in. They are for use in heavy hydraulic-cylinder applications for off-the-road equipment. Filled nylon has excellent wear resistance, requires no



lubrication, and is used as bearings in many applications. It has a wide temperature range, remaining serviceable to 350 F, has a low coefficient of friction, and will not gall cylinder walls on long-stroke pistons where canted reciprocation is encountered. **Garlock Inc.**, 445 Main St., Palmyra, N. Y.

*Circle 761 on Page 19*

## *Elapsed-Time Indicator*

**features digital readout**

Digital read-out elapsed-time indicator presents total elapsed-time data in direct-reading numerals approximately the size of typewriter characters. It facilitates data taking and substantially reduces the hazard of misreading, especially when access is difficult. Device incorporates a 50-rpm, tell-tale disc and integrates 1000 hr in 0.1-hr increments or 10,000 hr in 1-hr increments. Unit is small, lightweight, and extremely reliable. Weight, including hermetically sealed casing, is 1.6 oz. Read-out numerals are 0.080 in. high and 0.040 in. wide. Environmental tol-



*Circle 547 on Page 19*



**FROM COW PASTURE... TO CANAVERAL!**

From the era of the "$2 ride" to today's million dollar blast off's, the success of air vehicle performance has hinged on the reliability of components. Since 1933, Pesco products have been acclaimed for their proven dependability. As man prepares to meet the new challenges of flight, imaginative Pesco engineers are developing new concepts of reliability and . . . through creative engineering . . . are translating them into precision components to deliver volatile fuel, control the flow of hydraulic power, actuate guidance devices, generate and convert precise power, and cool vital working parts. Because today's high mach aircraft demand fail-safe operation, Pesco designs and builds components to *meet and exceed* all anticipated requirements to provide assured performance under critical operating conditions.

## PESCO PRODUCTS ASSURE RELIABLE PERFORMANCE FOR AIRCRAFT, MISSILES, AND SPACECRAFT

Engineering Pesco Production

BW

**PESCO PRODUCTS DIVISION**
**BORG-WARNER CORPORATION**
24700 North Miles Road • Bedford, Ohio

CONSULT PESCO FIRST FOR YOUR SPECIALIZED REQUIREMENTS IN . . .

- STATIC INVERTERS
- FREQUENCY CHANGERS
- CRYOGENIC COMPONENTS
- ENVIRONMENTAL COOLING
- AUXILIARY POWER SYSTEMS
- ELECTRIC POWER GENERATION

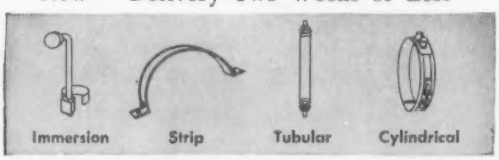
8701-PC

EXPORT SALES: Borg-Warner International Corp., 36 South Wabash Avenue, Chicago 3, Illinois



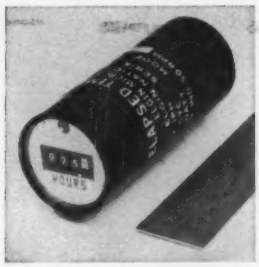

Watlow's FIREROD combines in one unit the best of all those factors most often sought in an electric cartridge unit: it's the *HOTTEST* heater going (gives you 5 times more heat than any standard unit, yet offers an amazing *heat range* up to 1500°F and higher) . . . the *LONGEST LASTING* cartridge operating at *any* temperature (will out-live, out-perform 5 to 10 ordinary heating units) . . . and the most *DESIGN-WISE* cartridge available today (the *same* heat you'd get in a standard unit, in 1/5 the space).

So . . . whether you're looking for high concentration of heat or longer-lasting cartridge heaters – you'll want to learn more about the FIREROD. WRITE for FIREROD BULLETIN #367.
Now — Delivery Two Weeks or Less




**WATLOW**
**ELECTRIC MANUFACTURING CO.**
1384 Ferguson Avenue
St. Louis 14, Mo.



erance covers temperature variation from −65 to +165 F, 20 g vibration over a 10-2000-cps range, and 15 g, llms shock. **Elgin Micronics Div., Elgin National Watch Co.,** 366 Bluff City Blvd., Elgin, Ill.

*Circle 762 on Page 19*

## Pipe Plugs

**seal tightly without sealing compound**

Lightweight Delrin pipe plugs are usable with all types of organic fluids. They seal tightly without sealing compound and will not loosen under severe vibration. Plugs are available in ⅛, ¼, ⅜, and ½-in. sizes in square heads, and ⅛ and ¼-in. sizes in hex heads. Hollow design inside the plug increases sealing ability. As pressure increases, plug threads are forced tighter against mating threads of hole. In pressure tests, plugs have withstood



from 3000 to 10,000 psi. **Russell, Burdsall & Ward Bolt and Nut Co.,** Dept. D, 100 Midland Ave., Port Chester, N. Y.

*Circle 763 on Page 19*

## Silicon Mesa Transistors

**for small-signal uses**

Line of small-signal silicon mesa transistors is available for applications such as audio and servo amplifiers, power supplies, and medium-speed switches. Included are 2N734, 2N738, 2N1564, and 2N1572 series.



*Circle 549 on Page 19*

## *New "Taylorite"® is a veritable workhorse*



Background photo courtesy Philadelphia Commercial Museum. Lighting Duct courtesy BullDog Electric Products Division, I-T-E Circuit Breaker Co.

## Improved Vulcanized Fibre... superior insulation, excellent forming characteristics

Dramatic highlighting of displays at the Philadelphia Commercial Museum is accomplished quickly and inexpensively with BullDog Universal Lighting Duct.® Fixtures can be added, moved and relocated anywhere along the duct run in a matter of minutes. Contributing to the effectiveness and safety of this modern lighting system is the formed Taylorite vulcanized fibre part used to insulate the conductors from the end caps. Taylorite was selected because it provides superior insulation, has excellent forming characteristics, provides good dimensional stability. Taylorite is ideal for the fabrication of many mechanical components, too. Its high impact resistance, flexibility, formability, toughness and capacity to be deep drawn make it adaptable to 1001 industrial applications.

Samples are available. Test them for yourself. Put them under tension, flex them, compress them, form them. You will find that new Taylorite will pass your severest tests with flying colors. And remember, Taylor offers complete design and engineering assistance.

**Write for Data Sheet 2-0 and samples. Taylor Fibre Co., Norristown 47, Pa.**



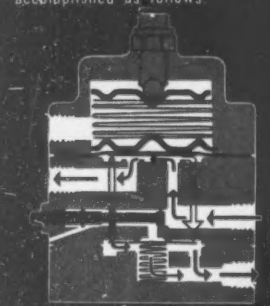



Circle 550 on Page 19

PACKAGED
*pneumatic*
CONTROL
*automatic or manual trip or reset* = "MITE"




The "MITE" is a snap-acting, adjustable pneumatic switch and/or relay.
Venting, lock-up and switching are accomplished as follows:



A – Air Signal Input
B – Signal Output (Lock up on trip)
C – Signal Output (Vent on trip)
D – Remote Pneumatic Trip
E – Remote Pneumatic Reset
F – For Loading to Nullify "E"
G – TRIP TO OPEN (To "H")
H – Common to "G" and "I"
I – TRIP TO CLOSE

*Get complete details on the "MITE" Series today*

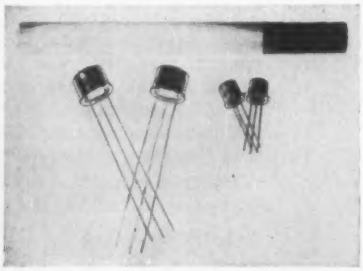
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BRISTOL, RHODE ISLAND
CLifford 3-9500

VALVES AND CONTROLS FOR THE COMMUNICATIONS, PROCESS AIRCRAFT AND MARINE INDUSTRIES

Circle 551 on Page 19




Ease of design is facilitated by a choice of TO-18 or TO-5 cases. TO-5 packaged units offer an additional 100 mw free air power dissipation as compared to the TO-18 where space is not critical, while new TO-18 package meets miniature transistor needs. Units in the TO-5 package have a power dissipation of 1200 mw at 25 C case



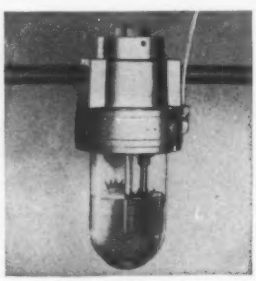
temperature and 600 mw free air. TO-18 packaged units have 1000 mw dissipation at 25 C case temperature and 500 mw in free air. **Semiconductor-Components Div., Texas Instruments Inc.**, P. O. Box 312, Dallas 21, Tex.

*Circle 764 on Page 19*

### *Lubrication Device*

**operates on pressure variations**

Crown pulse lubricator delivers exactly the required amount of oil to the spot where lubrication is needed. System operates on pressure variations (pulses) and is entirely independent of air flow rates and duration of flow periods. Because outlet end of the oil-delivery line can be placed in any location, oil delivery to the exact spot desired is assured without the need for auxiliary pressurized oil supply. Unit provides positive lubrication of air-operated equipment even when equipment is located in high, overhead places, or when air flow through the lubricator is very low






*Theme Tower Symbol of the 1960 Metal Show*

Learn a lot about design at the

NEW METAL SHOW!

"ASM brings together in one place and at one time the year's most important developments in the technical and practical aspects of the metals industry. Never have I left a show without several ideas for applications of materials, equipment or processes in my engineering work. The 1960 Metal Show promises me more 'take home' than ever."



Raymond J. Hibbeln
Dept. Chief, Product & Development Engineering
WESTERN ELECTRIC COMPANY

Design engineering experts know the value of the 1960 Philadelphia Metal Show — how stimulating it will be — and that's why they plan to attend. They know that a new emphasis on the essential metals and materials, processes and techniques will make the 1960 Show more valuable than ever before . . . providing some 300 exhibits and 250 technical papers. Attendance will be a sound investment for you and your company!

**October 17-21**
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**Philadelphia Trade & Convention Center**

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*Metals Park • Novelty, Ohio*

Circle 552 on Page 19



*for a quality product*

*use a quality "O" ring*

**be safe with PRECISION!**



Precision "O" Rings are engineered specifically for your product! They're made to do the job better... longer. They meet all military and commercial specifications. Precision "O" Ring quality is maintained by over 100 inspections and quality control tests. There's a size and compound to meet YOUR requirements. If it's Precision – it's Precision-made! Write, wire, or phone for data sheets or help of a Precision Sales Engineer today.

**Precision Rubber Products** Corporation

*"O" Ring and Dyna-seal Specialists*

**Dept. 431, Oakridge Drive, Dayton 7, Ohio** **Canadian plant at: Ste. Thérèse de Blainville, Québec**

# The Mastergauge GROUP



and companion "Master-test" group for extreme services requiring the ultimate in accuracy and stamina.

# Right Quality GROUP



also for tough services, but less severe than the conditions served by the "Mastergauge"

# Gauge Standard GROUP



for the general run of gauge services. Marsh quality and accuracy at a moderate price.

# for every need

Within these three comprehensive Marsh groups you have the world's widest (yes, and wisest) selection of pressure gauges. These groups of gauges are not *grades* ...they are *kinds*...the MARSH kind... which means that each gauge, within the scope of its rated use, is the BEST of its kind!

Pick the right Marsh Gauge and you have the best answer to your gauge problem.

*Ask for latest data*

**MARSH INSTRUMENT COMPANY**

Division of Colorado Oil & Gas Corporation, Dept. B, Skokie, Ill. Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

**MARSH**

GAUGES • THERMOMETERS VALVES

Circle 554 on Page 19




and/or infrequent. Lubricator delivers a metered amount of oil and controls the amount of oil feed accurately. **Hannifin Co., Div., Parker-Hannifin Corp.**, Dept. 116, Des Plaines, Ill.

Circle 765 on Page 19

## Miniature Heater

for use to 800 F

Miniature heater rated from 20 to 75 w for voltages from 6 to 115 v ac or dc is now available. Heater has a small opening through the center line for passing a fluid to be heated, or a wire that should be heated to as high as 800 F. Heating



unit is encapsulated and enclosed in heat and shock-resistant ceramic. Unit can be used as a heater for fluids, small instruments, paint-spray nozzles, and other devices where the operation is based on a rapid, thermal response. Units are constructed for intermittent or continuous duty. **Sorrels-Johnson Corp.**, 363 Rantoul St., Beverly, Mass.

Circle 766 on Page 19

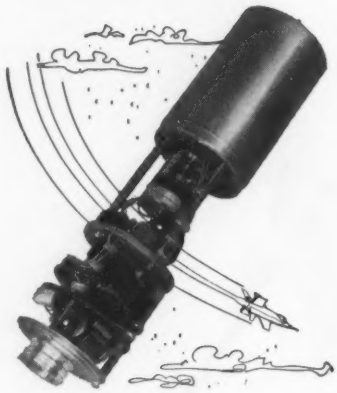
## Precision Ball Bearing

operates at temperatures to 575 F

Developed primarily for airborne applications, Bartemp precision ball bearing operates at temperatures to 575 F without conventional lubrication. It is designed for the needs of newer types of synchros, motors, blowers, and fans that operate at higher temperatures than their predecessors. Bearing utilizes a ball retainer of reinforced Teflon compounded with a solid lubricant, a material with a coefficient of friction equal to that of pure Teflon, which provides a high resistance to deformation under load. Machined into one-piece ball retainers, material serves both as a dry lubricant


SPECTROL PRECISION MECHANISMS

# Pilot to Cockpit to Control



When a test pilot rockets into the outer atmosphere for the first time driving experimental craft such as North American's X-15, he'll feel as though he's been there before.

Before his first actual flight, the pilot trains for many hours in "dry land" rocket craft. There, he learns to cope with upper atmosphere problems as posed by an analog computer. Every time he touches a control, the computer responds and the result appears on the instrument panel in the training cockpit. The entire bank of instruments reacts as though he were really "up there." In this way, the pilot meets every conceivable situation long before he takes his powerful bird aloft.

And what does Spectrol have to do with this important training program?

Spectrol makes the link that joins the computer and the bank of instruments in the cockpit. This link, known as a servo repeater, translates the computer's information into meaningful dial readings. As you know, such information must be transferred quickly and accurately.

Spectrol servo repeaters do just that. Key specifications for a typical unit now in production are:

Maximum velocity: 360°/sec
Acceleration in excess of 7000°/sec²
Static accuracy better than 0.25 deg. at output shaft

Other applications for Spectrol packaged servo repeaters include dial drives on GCA equipment, airborne computers and dc systems in general.

Spectrol PRECISION MECHANISMS free the systems engineer from building functional sub-assemblies. If you need precise logical system modules combining in a *single specification* sub-assemblies using components such as gear drives, clutches, precision potentiometers and servomotors —Spectrol can help.

*For complete information, call your nearest Spectrol engineering sales representative, or address Dept. 63.*

14

SPECTROL

**ELECTRONICS CORPORATION**
1704 SOUTH DEL MAR AVENUE • SAN GABRIEL, CALIF.

Circle 555 on Page 19

# Would you spend an extra 10%



# to double roller chain life?

**Morse H-E Roller Chain overcomes metal fatigue . . .**

**lasts from 2 to 5 times longer . . .**

**costs only 10 per cent more than ordinary roller chain!**

Yes, now by paying just a slight premium you can buy Morse H-E (high endurance) roller chain . . . and get 2 to 5 times the service life over ordinary chain. Here's why:

Normal roller chain breaks sooner under the rigors of "stop-and-start" or heavy strain operations. It's this "tired metal" problem that plagues anyone who has used roller chain. Morse has developed a process to overcome metal fatigue. As a result, Morse H-E Roller Chain has a 95% greater endurance limit . . . lasts up to 500% longer . . . costs just 10% more.

Make a test yourself. Next time you need roller chain, try Morse H-E and compare. Your Morse Chain distributor is the man to see. He's listed in the Yellow Pages under "Power Transmission." Or write: Morse Chain Company, Dept. 6-90, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

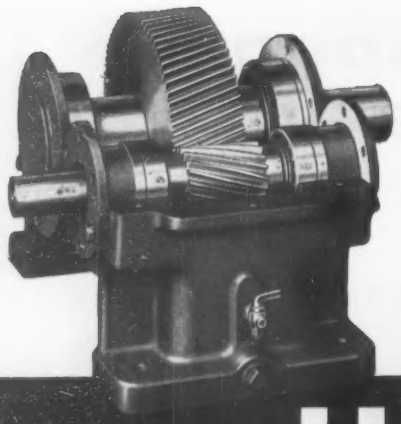


ORDINARY CHAIN BREAKS when the side plate tires from repetitive loading and unloading during the cycle around the sprockets. But Morse H-E Roller Chain has a 95% higher endurance limit . . . outlasts ordinary chain by up to 5 to 1 under repeated loading.

**MORSE** BW T.M.

A BORG-WARNER INDUSTRY

**ONLY MORSE OFFERS ALL FOUR: Roller Chain, Silent Chain, Hy-Vo® and "Timing"® Belts**



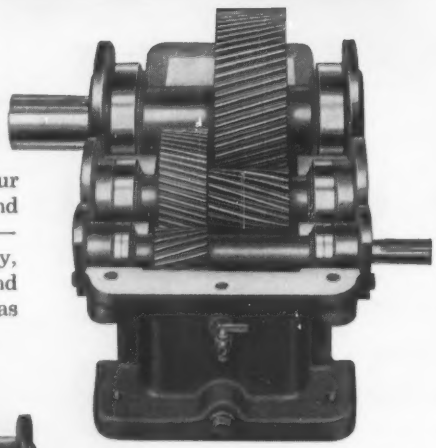
Fast Delivery on Custom Requirements

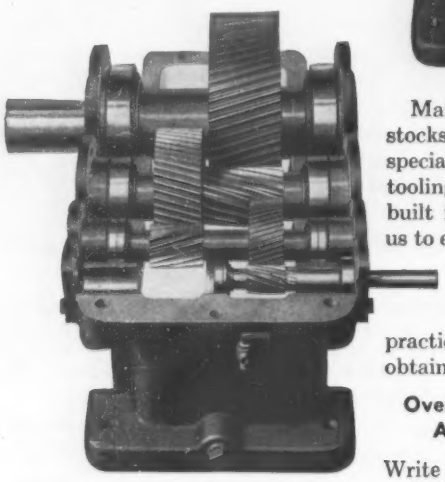
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You get *fast action* when you come to Horsburgh & Scott with your speed reducer and gearing problems.

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**Overall design conforms to AGMA specifications**

Write for details on wide size and capacity range of H&S Speed Reducers—Helical, Herringbone, Worm Gear and combinations.

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Specializing in fast production of quality Speed Reducers and Gearing to meet custom requirements.



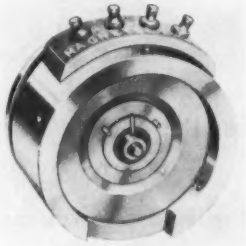

and a separator for the balls. As the bearing rotates, balls rub off microscopic quantities of the lubricant, depositing a light coating on the raceways. Unit withstands axial and radial loads to 2 lb, and can operate in air, most gases and liquids, and vacuums. Prototype quantities of several sizes of the bearings from 0.3125 to 0.7480 in. OD are now available in angular-contact, separable and nonseparable types, the latter with or without shields. **Barden Corp.**, Danbury, Conn.

*Circle 767 on Page 19*

## Magnetic Clutch

**has over-all length of less than 5/8 in.**

Features of a new recentering magnetic clutch include provision of a cavity for potentiometer winding, synchro windings, or switches, facilitating marriage of clutching with function to be performed. Unit



has over-all length of less than 5/8 in. Recentering spring torque is not applied until clutch is disengaged. Operational torque is thereby kept to an absolute minimum, making the unit ideal for gyroscope pick-off applications. Dual-winding coil construction permits 12 or 24-v operation, depending on application. **Magnetec Corp.**, 7232 Eton Ave., Canoga Park, Calif.

*Circle 768 on Page 19*

## Two-Step Adhesive

**for bonding nylon to metal**

Two-step process for chemically "welding" nylon to metal is expected to find use in such applications as the bonding of nylon gears to metal shafts, or the securing of threaded screws or rods in nylon-and-metal assemblies. Epoxy paste chemically



*Circle 557 on Page 19*

*Circle 558 on Page 19→*



# do you know these facts about this fabulous plastic?

**Do you know that:**

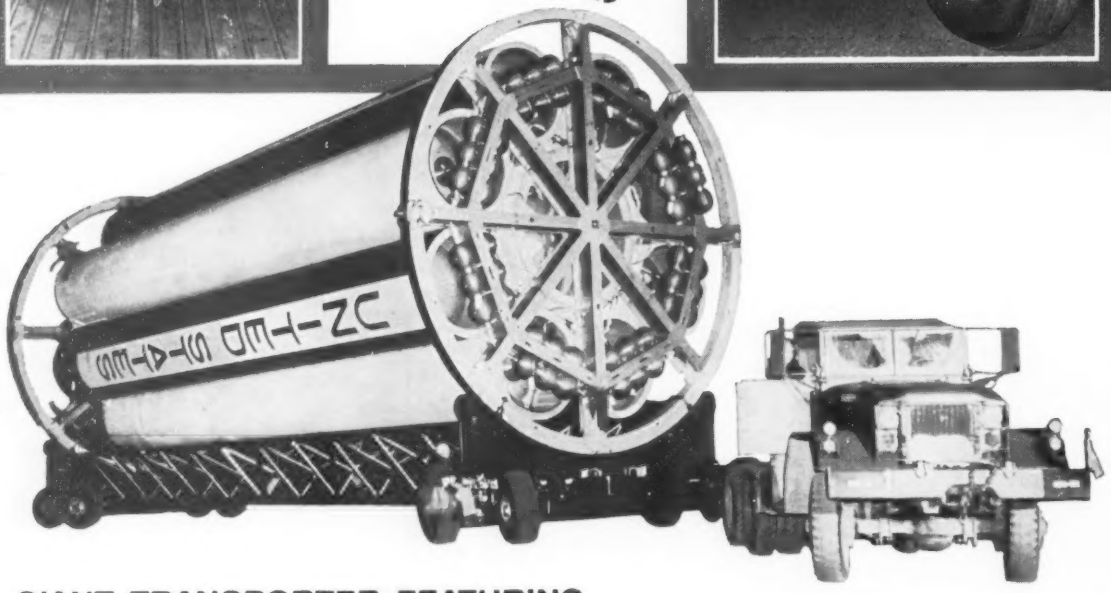
- National Vulcanized Fibre is not a paper, or a fiber-board, but a tough cellulosic plastic . . . the oldest plastic of all!
- Despite a parade of new exciting plastics (and we make many of them), Vulcanized Fibre goes on sparking thousands and thousands of bright, new, cost-cutting ideas that other plastics aren't equal to!
- Vulcanized Fibre offers a most unusual combination of electrical and mechanical properties, giving your imagination more leeway, and *you* a greater chance of fingering the exact properties you want!
- National Vulcanized Fibre has outstanding arc resistance, low thermal conductivity, amazing resiliency and shock-absorbency, high abrasive resistance. It is fungus resistant. It soaks up noise!
- National Fibre can be formed or deep-drawn into intricate shapes; and machined, polished, painted, lacquered, embossed . . . even used in combination with other materials, such as aluminum, wood, rubber, copper.
- When used for railroad track insulations, Vulcanized Fibre can take the constant pounding of trains, yet can gently *cushion* fragile electronic parts, when used for containers. And it has stood up under 22,000° F for ten seconds without serious loss in weight!
- Vulcanized Fibre weighs half as much as aluminum, one-third as much as steel, is smooth as glass, and is one of the *strongest* materials known per unit of weight!
- There are sixteen standard grades, including a fire-resistant "Pyronil." And the cost of National Vulcanized Fibre is in the cents bracket, compared to dollars for many other types of plastics.
- *This* could be the plastic you are looking for now!

For help on a present problem, or for information on National Vulcanized Fibre and samples, just write Dept. RR, or contact your nearby NVF Sales Office. You'll find the 'phone number in Sweet's Product Design File 2b/Na.

**NATIONAL**
**VULCANIZED FIBRE CO.**
WILMINGTON 99, DELAWARE

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**GIANT TRANSPORTER FEATURING ACIPCO "WALKING BEAM ASSEMBLIES" WILL HELP...**

# Saturn's conquest of space

The moment draws near when America's Saturn rocket will thunder into space. But in the meantime, elaborate ground preparations are now taking place.

From the N.A.S.A. Marshall Space Flight Center in Huntsville, Alabama, via a circuitous land and water route to the launching site, the missile and its valuable cargo will be gently cradled on the huge transporter shown here. Acipco walking beam assemblies (upper left) are vital parts of this transporter.

These rugged assemblies are constructed of high strength alloy steel and comprise centrifugally spun and statically cast component parts . . . all produced at Acipco. Also, all precision machining and intricate fabrication work were done by skilled Acipco personnel.

While your tubular product application may not be destined for outer space, Acipco's production "know how" and complete "under one roof" facilities can assist you, too. Your inquiry is invited.

ACIPCO
SPECIAL PRODUCTS
DIVISION OF ACIPCO AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA



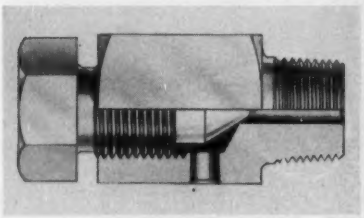
Circle 559 on Page 19

unites with metal surface on which it is applied, and separate solvent solution applied to the nylon part softens the surface and allows nylon molecules to blend with epoxy bonding agent as it hardens. Entire operation is performed at room temperature, achieving an extremely tough, shock-resistant union between nylon and metal within a few hours. Two materials used in the system are supplied in separate containers. Nylon treating agent, designated PA-749, is a single-component material, and bonding agent, PA-708, is a two-component material. **Plastic Associates,** 2900 S. Coast Blvd., Laguna Beach, Calif.

*Circle 769 on Page 19*

### *Air Bleeder Valve*

**for use at highest point in the hydraulic circuit**



Air-bleeder valve for hydraulic circuits is designed to be installed at the highest point in the hydraulic circuit, the point at which air accumulates. It permits elimination of all air from the system for maximum operating efficiency, and is especially important when a hydraulic system is started. Valve is of compact, functional design with only two metal parts. No packings are employed. Valve is available in a range of popular sizes in cadmium-plated steel, and in stainless steel on special order. **Lenz Co.,** 3301 Klepinger Rd., Dayton 1, Ohio.

*Circle 770 on Page 19*

### *V-Link Belting*

**is made with synthetic blended-filament yarns**

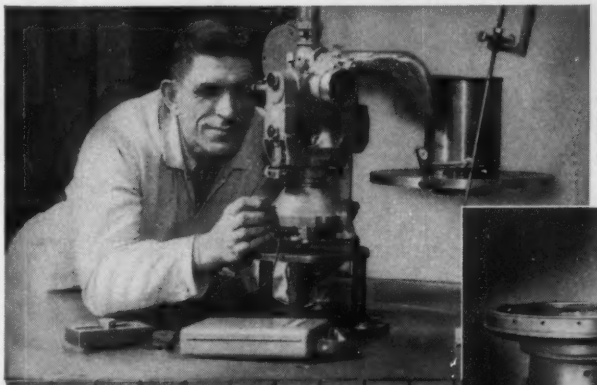
Improved detachable V-link belting, Hypowa, is made with synthetic blended-filament yarns. Belting increases horsepower ratings, adds longer life, and reduces stretch and vibration. It is available in all sizes

(*Please turn to Page 274*)

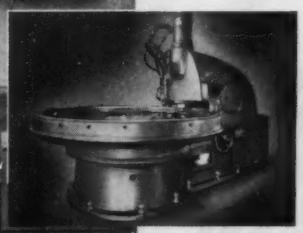

# BRAD FOOTE gears ...FOR A WORLD AT WORK

## SUPERIOR TESTING METHODS

**give you gears cut to maximum accuracy and precision**



◀ Theodolite accurate to within 0°-0′-0.2″ of arc being used to check indexing of 154″ gear shaper



▲ Special 154″ gear shaper reworked by BRAD FOOTE for cutting precision gearing




▲ Actual graph of index wheel accuracy readings in seconds of arc at each 3° (rotation) interval

BRAD FOOTE's constant striving for higher quality leaves nothing to chance. Constant checking of all gear-cutting machines assures all gears are cut accurately to the closest possible tolerances.

Here a BRAD FOOTE inspector uses a Theodolite to verify the accuracy of the worm wheel of a large 154″ gear shaper. This instrument is capable of readings accurate to within 0°-0′-0.2″ of arc between adjacent readings.

It is through such painstaking attention to every detail of manufacture... from blanks to finished precision gears... that BRAD FOOTE maintains a rigid standard of excellence which is recognized throughout industry.

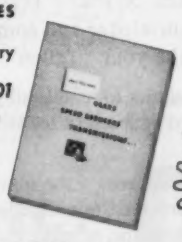
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*Your order for BRAD FOOTE Gears will be processed by an experienced organization of gear specialists and produced on the most extensive and versatile facilities available. Maximum performance and your complete satisfaction are assured because no one shares our responsibility.*

**OTHER SPECIALIZED BRAD FOOTE INSPECTION FACILITIES FOR TESTING:** Involute • Lead • Tooth Spacing • Rod Line Dial Bridge Gage • Metalography Laboratory



*Send for new Bulletin #101 Find out what BRAD FOOTE's two generations of gear building experience can do for YOU. Write today*



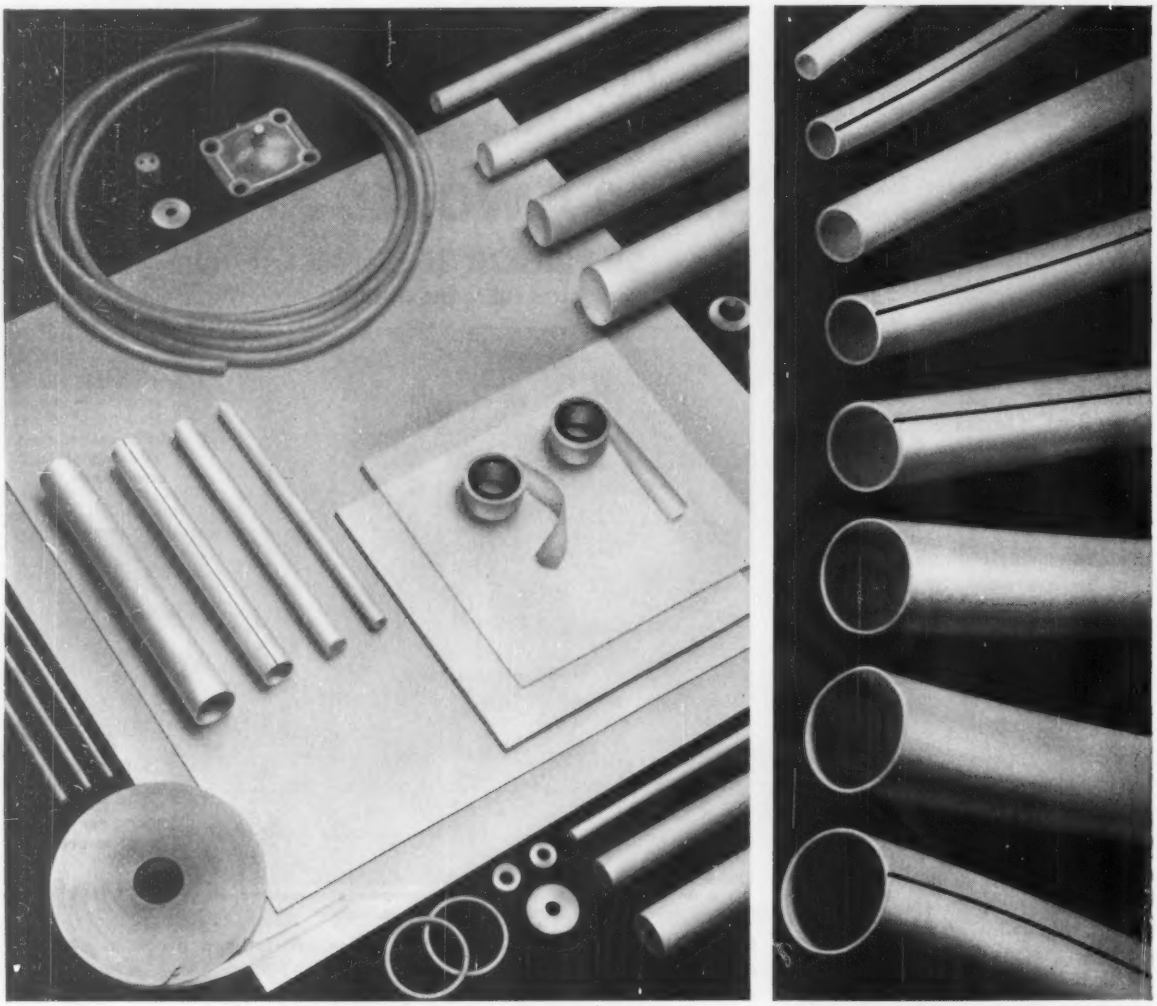
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subsidiary • PITTSBURGH GEAR COMPANY, Neville Island • Pittsburgh 25, Pa., Phone: SPaulding 1-4600

# *Designers think of R/M first for asbestos, rubber,*



R/M tubes, rods, sheets, tape, thin-wall tubing and new color-coded thin-wall tubing

# How R/M TEFLON* capabilities cut design costs

The cost of designing with "Teflon" is directly related to the capabilities of your "Teflon" source. Here is how the proved knowledge and complete service of R/M can help you make your "Teflon" dollars work harder.

**Production facilities** to handle all your "Teflon" requirements . . . in standard or special sizes and shapes . . . in any quantity you need.

**Engineering assistance** on the spot to help you simplify parts, improve performance, minimize fabrication by designing with a stock size and shape, or make use of a more efficient fabrication method.

**"Teflon" research** in application and fabrication brings you a constant flow of new "Teflon" products. Color-striped thin-wall tubing, square convolution expansion joints, bondable "Teflon" and 1/32-in.-thick 36 in. x 36 in. sheets are recent examples. If you have a special application, R/M engineers are ready to assist.

**Authoritative product information,** which only an industry leader can provide so well, is available to you from your nearby R/M district office . . . or write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

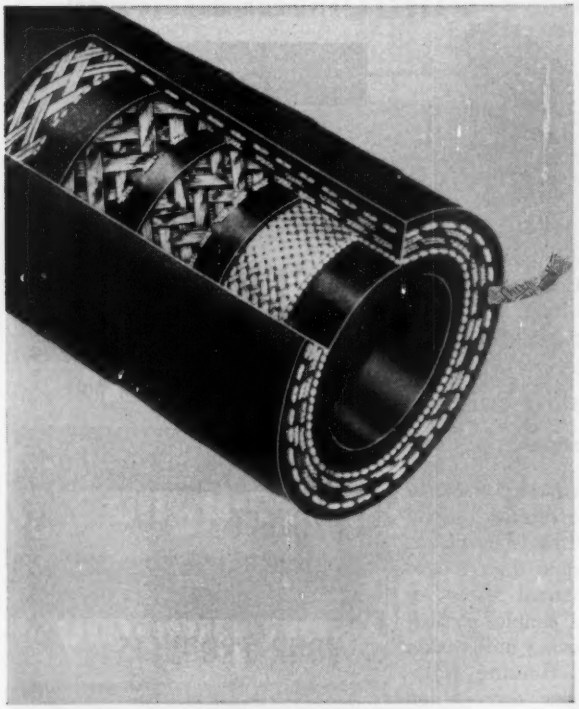
*A DuPont trademark

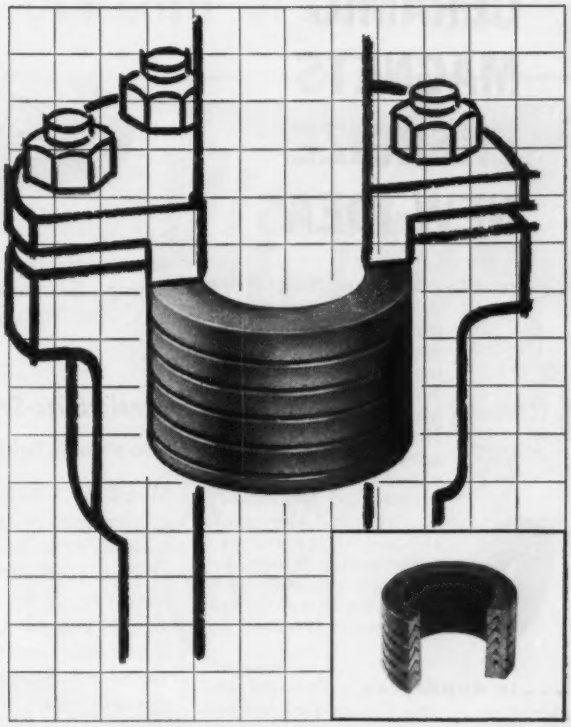
**PLASTICS**



Ask for a copy of this booklet on the complete R/M line of "Teflon" Products.

# *sintered metal, and engineered plastic products*





## THE STRENGTH OF STEEL . . .

### In R/M's Non-Burst BW Steam Hose

R/M offers a full line of precision-built hose for every steam application at saturated pressures to 200 lbs., 388° F. Strength and durability are employed throughout the construction of Super-Master BW Steam Hose, illustrated above. Two braids of high-tensile, multiple end, non-corrosive steel wire are applied at a controlled angle over an asbestos-covered inner tube of thick steam-resistant rubber for greatest strength with minimum elongation and contraction, and provide positive protection against bursting. Cover is of special Butyl rubber to resist heat and weather. Sizes from ½ to 2 inches.

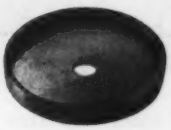
The strength of steel, the heat resistance of asbestos, the flexibility of rubber, the static dissipating wire, all in Super-Master BW Steam Hose . . . the safest high-pressure steam hose made. Write for Bulletin M630.

## *R/M CAPABILITY*

### develops industry's most effective packings— R/M Vee-Flex® Packing Rings and Fabric Piston Cups

R/M Vee-Flex Packing Rings and R/M Fabric Piston Cups are both examples of the ability to produce outstanding packings for hydraulic and pneumatic applications.

R/M Vee-Flex Rings are self-adjusting and self-sealing; are designed so that pressure automatically expands the lip on the pressure stroke, forming a tight seal against the stuffing box wall and shaft. On the return stroke, the ring assumes a relaxed position, thus reducing wear.



R/M Fabric Piston Cups are designed for minimum friction, highest resistance to extrusion, and positive sealing action. Uniform dimensions, clearly defined contours, and cleanly trimmed edges are characteristics. Both duck and synthetics and asbestos and synthetics are available.

R/M's vast experience in design, compounding and manufacturing of mechanical packings and gasket materials is at your disposal.

**RUBBER**



Write today for free booklet shown: full details on a wide variety of industrial rubber products. Manhattan Rubber Division, Raybestos-Manhattan, Inc., Passaic, N.J.

**PACKINGS**



Write for free booklet giving complete information on R/M Molded Hydraulic and Pneumatic Packings, Packing Division, Raybestos-Manhattan, Inc., Passaic, New Jersey

## RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

RM

Circle 562 on Page 19A

Circle 563 on Page 19A

# HOW CERAMIC MAGNETS ENERGIZE NEW IDEAS

***. . . in Liquid Flow Registers***



Water and liquid meters can be read at a distance with the remote-indicating "Read-O-Matic" Register of the Badger Meter Mfg. Co., of Milwaukee. Heart of this self-contained generator is an inexpensive 6-pole ring magnet of Stackpole Ceramagnet. The quick release of the magnet under spring tension induces a 3-volt pulse in 6 coils. This is transmitted to a remote totalizer.

***. . . in Appliances*** • Powerful, low cost Ceramagnet ceramic permanent magnets open, close and hold doors; put *snap* into snap-action switches and thermostats; catch lids from can openers . . . make other magnet uses practical for the first time. Ceramagnet requires no keepers; retains magnetism indefinitely, can be molded in practically any shape.



***. . . in Automotive Equipment***



High coercive force and high electrical resistivity make Ceramagnet ideal as field magnets in small dc motors. They are likewise being investigated for fuel-pump drives, speedometers, ammeters, carburetors, and many other new devices.

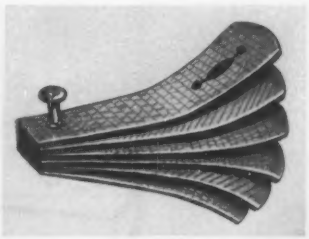
*Where can YOU use Ceramagnet? For practical suggestions, and engineering details, write for Stackpole Bulletin, RC-12A. STACKPOLE CARBON COMPANY, St. Marys, Pa.*

STACKPOLE Cera MAGNET®
FERRITE PERMANENT MAGNETS

Circle 564 on Page 19




(*Continued from Page 271*)



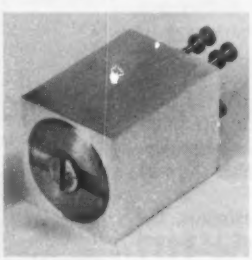
at no extra cost over conventional belting. **Brammer Corp.**, 486 Broadway, New York, 13 N. Y.

Circle 771 on Page 19

## Acceleration-Sensitive Switch

**in a small, light package**

Model AS-4 switch is responsive to acceleration in one direction along a single axis. Resetting is by means of high acceleration in the opposite direction, or by manual reset. Design is rugged and simple, consisting of only one moving unit within the switch housing. Housing is aluminum, and interior construction can be of nonmagnetic materials, resulting in completely nonmagnetic components. Suited for commercial, industrial, and military applications where acceleration-sensitive switching is desired, unit pro-



vides reliability and ruggedness in a small light package. Weight is only 3 oz, and size is $\frac{3}{4}$ x $\frac{3}{4}$ x $1\frac{1}{2}$ in. Response time is less than 50 millisec. Temperature range is −65 to +250 F. **Eastern Technical Associates Inc.**, Main Street, North Acton, Mass.

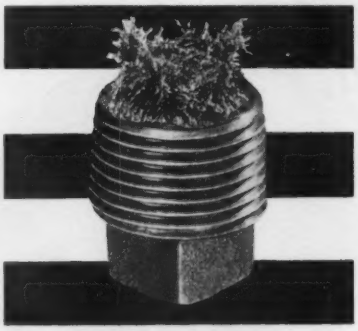
Circle 772 on Page 19

## Brake-Motor

**is up to 6 in. shorter than standard equivalent-rated units**

Thinline brake-motor is up to 6 in. shorter and as much as 20 lb lighter than standard brake-motor de-


this much abrasive metal . . .



can destroy precision parts!

PROTECT

YOUR PRODUCTS

WITH LOW COST

LISLE *Magnetic* PLUGS

If your product has moving parts operating in a fluid, you can reduce costly wear with Lisle Magnetic Plugs.

Ferrous metal particles in a lubricant are a major cause of wear. The Lisle Magnetic Plug removes these particles from the lubricant — assures longer, quieter operation of the products you make.

Lisle Magnetic Plugs can be used in place of any ordinary drain or fill plug.

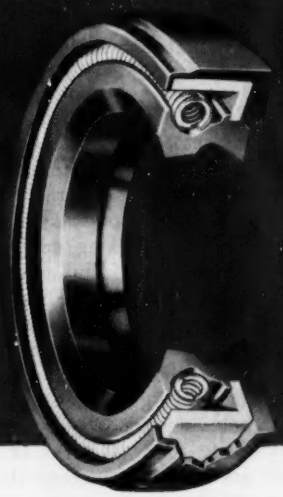
**FREE** Samples for Testing in Your Product!

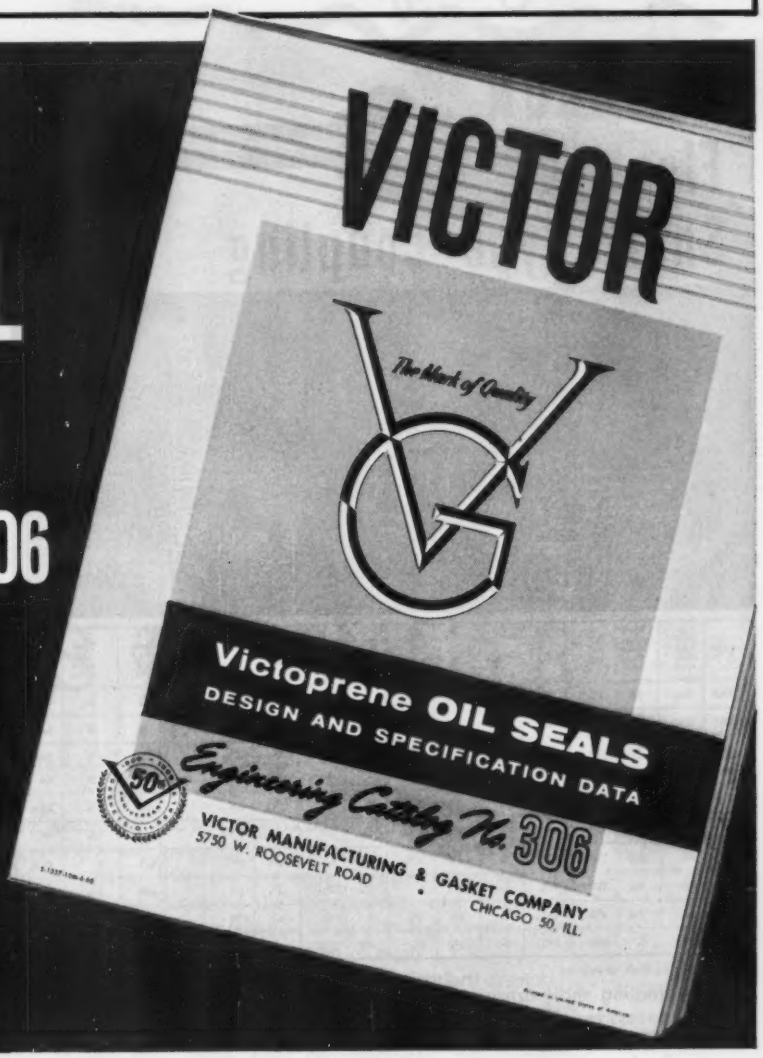
LISLE CORPORATION
Clarinda, Iowa

Circle 565 on Page 19

# HANDIEST GUIDE FOR SEALING SPECIFIERS

## NEW OIL SEAL engineering catalog No. 306






You get all essential data—from basic approach to specification—for modern oil sealing practice, in this new Victor catalog. Every section offers valuable help in choosing the right oil seal and insuring effective performance on your application.

Convenient to use, this catalog gives you close-up exposition of standard structures—metal-encased, one-piece molded, and split seals. The general characteristics of synthetic rubber oil seal compounds are covered in detail, with service ratings. Specific recommendations are given on design adaptability in relation to sealing pressure, temperature, and shaft speed. All this in addition to a complete listing and size data on all available standard-type Victor quality oil seals!

**Your copy FREE on request**

Depend on this new catalog to give you complete, up-to-date information for all your oil seal needs—standard or special. Write for your copy today—ask for Catalog No. 306.

If you have a special oil seal need, Victor's engineering staff and leading production facilities can help you fill it most economically. Talk it over with your Victor Field Engineer—no obligation.

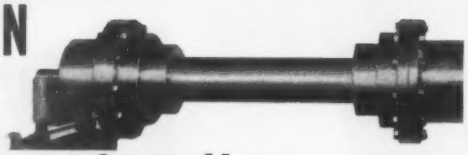
Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

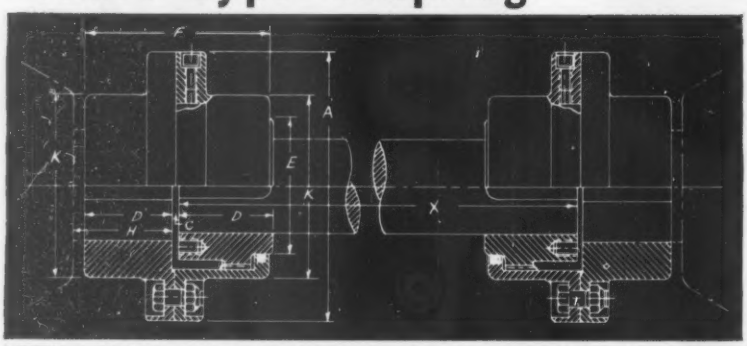
**VICTOR** Sealing Products *Exclusively*

**OIL SEALS • GASKETS • PACKINGS • MECHANICAL SEALS**

design facts....on

# WALDRON Floating Shaft Type Coupling






| Size | Max. Over Bore Flex. Half | Max. Over Bore Rigid Half | H.P. Per 100 R.P.M. | A | C | D | D¹ | E | F | H | K | X | Ship. Wt.* in Lbs. | Total Oil Req'd in Pts. | Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Dimensions in Inches | | | | | | | | | | | |
| 1¼A | 1⅛ | 1⅜ | 3½ | 4⁵⁄₁₆ | ⅛ | 1½ | 1¹¹⁄₃₂ | 2 | 2⅜ | 1½ | 2¹¹⁄₁₆ | | 22 | ⅓₀ | 1¼A |
| 2A | 2⅛ | 2½ | 12 | 6 | ⅛ | 2¼ | 1²⁹⁄₃₂ | 2⅞ | 4 | 2⅛ | 3¹³⁄₁₆ | | 42 | ⅛ | 2A |
| 2½A | 2⅝ | 3 | 26 | 7 | ⅛ | 2¹⁄₁₆ | 2⅝₂ | 3⅝ | 4¾ | 2⅝ | 4²⁷⁄₃₂ | | 70 | ¼ | 2½A |
| 3A | 3⅜ | 3¾ | 50 | 8⅛ | ⅜ | 3¹⁄₃₂ | 2²⁷⁄₃₂ | 4¼ | 5⅞ | 3⅜ | 5⅜ | | 120 | ½ | 3A |
| 3½A | 3¾ | 4¼ | 86 | 9⁵⁄₁₆ | ⅜ | 3¹⁵⁄₃₂ | 3¹³⁄₃₂ | 5 | 7 | 3¾ | 6¾ | | 160 | ½ | 3½A |
| 4A | 4¼ | 4⅞ | 130 | 11 | ⅛ | 4⅛ | 3¹⁵⁄₁₆ | 5¾ | 8⅛ | 4½ | 7¹⁵⁄₁₆ | | 215 | ¾ | 4A |
| 4½A | 4¾ | 5⅜ | 210 | 12½ | ⅛ | 4¾ | 4¹³⁄₃₂ | 6½ | 9⅛ | 4¾ | 8²¹⁄₃₂ | | 350 | 1 | 4½A |
| 5A | 5½ | 6½ | 300 | 13⅜ | ⅛ | 5⅛ | 5 | 7½ | 10⅛ | 5¼ | 10⅛ | | 460 | 1½ | 5A |
| 5½A | 6 | 7¼ | 410 | 15⅝ | ⅛ | 6⅛ | 5¾ | 8 | 11⅞ | 6 | 11⅜ | | 650 | 2 | 5½A |
| 6A | 6½ | 8 | 550 | 16⅝ | ⅛ | 6⅝ | 6⅛ | 8¾ | 12⅝ | 6⅝ | 12⅝ | | 820 | 2½ | 6A |

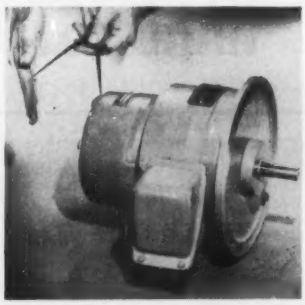
*Weight of Floating Shaft not included.

The floating shaft arrangement meets the problems of remote drives and excessive misalignments. This arrangement consists of two rigid female hubs on the driving and driven machines with a male half of a standard coupling on each end of the floating shaft, that separates the connected machines. The length of the floating shaft is limited by the critical speed, since this arrangement requires no intermediate bearings. The hub arrangement can be reversed, that is, the rigid hubs can be installed on the floating shaft and the flexible halves on the driving and driven machines. This arrangement is optional, except that it is better practice to have the rigid hubs on the driving and driven machines in the event that it is necessary to run the machines independently.
Write for Catalog.

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.



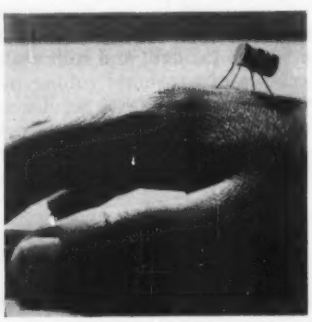
signs of equivalent ratings. Motor is designed for use on hoists, cranes, conveyors, machine tools, printing presses, laundry equipment, and saw mills. Frame and endshields are of rigid cast-iron construction. Initially offered in dripproof construction only, brake-motor is available in polyphase ratings of 1-5 hp at 1800 rpm, ¾-3 hp at 1200 rpm, and ½-2 hp at 900 rpm. **General Electric Co.**, Schenectady 5, N. Y.

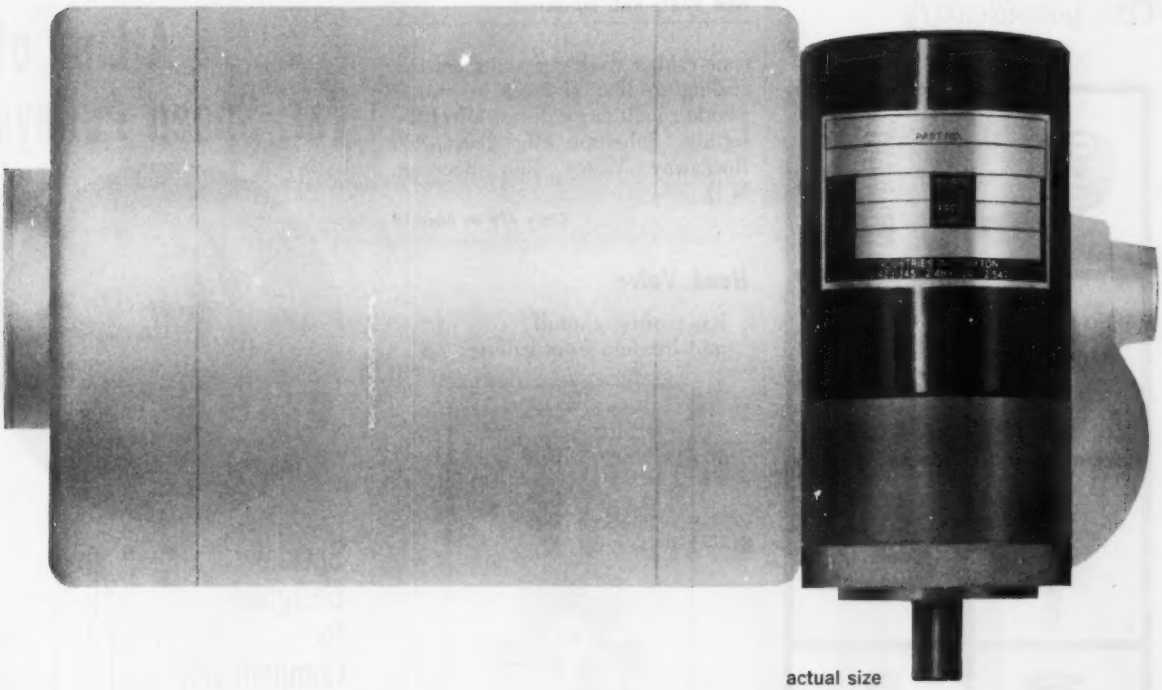
*Circle 773 on Page 19*

## *Precision Air Capacitor*

**miniature unit is adjustable from 0.8 to 10 mmf**

Type 2951 miniature precision air capacitor has applications in many missiles, computers, and other electronic devices where fine tuning is desired. Despite its small size, less than ½ in. long and ¼ in. OD, capacitor is fully adjustable from 0.8 to 10.0 mmf. Fine thread of its adjusting screw permits exactitude in the desired capacitance. Internal spring fingers with a Teflon disc-lock guarantee that value is held despite shock or vibration. More than 10 turns of the screw are required to cover the complete capacitance range, which varies linearly with each turn. Air is the dielectric in the high-Q capacitor. After the desired capacitance has been achieved, a cap with a sili-





actual size

# GEARMOTORS 3/4 SMALLER

The Globe a.c. gearmotor you see superimposed against a conventional right-angle gearmotor will give your product major advantages: Globe's version is much smaller than the big style, is interchangeable with slight mounting changes, produces the same torque, and should run 5 to 7 times as long without maintenance, even with high inertia loads. Study the picture above with **your** application in mind.

Furthermore, Globe gives you a choice of 101 **standard** planetary gear ratios, and any special ratios or other features you need. The Globe gearmotor is competitive in cost even though it meets military specifications. If you don't have rigid environmental requirements Globe can furnish a commercial version in production quantities at a saving to you. If you design with induction or hysteresis synchronous gearmotors—investigate now.

Globe has available for **immediate** shipment prototypes of the Type FC, 115v. a.c., 60 cycle synchronous motor in the following gear ratios: 352.6 to 1 (10.2 rpm, 160 oz. in. out), and 27.94 to 1 (64.4 rpm., 19 oz. in. out). Other variations, including d.c., about 4 week delivery. Please request Bulletin FCB from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE

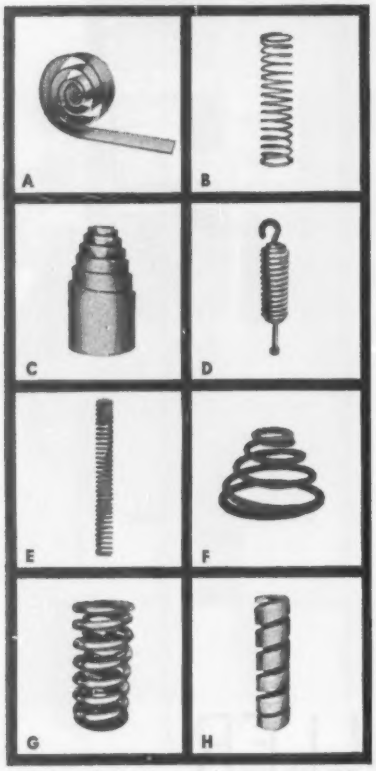
**GLOBE INDUSTRIES, INC.**

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, STEPPERS, BLOWERS, FANS, MOTORIZED DEVICES



Circle 568 on Page 19

*Can you identify these springs?*




A. flat B. helical C. volute D. extension E. helical F. cone G. helical, triple-coil H. rectangular section

**Over One Million**

**ALCO SPRING DESIGNS**

ALCO's complete line of "performance-rated" springs ranges from small springs for light work to heavy-duty triple-coil springs for heavy, sustained work.

In over 80 years, ALCO engineers have produced more than one million spring designs to serve almost every conceivable application.

For your next spring job, contact your nearest ALCO sales office. To obtain brochure, ALCO *Springs for Industry*, write to ALCO Products, Inc., Dept. 160, Schenectady, N. Y.

ALCO

**ALCO PRODUCTS, INC.**
NEW YORK
SALES OFFICES IN PRINCIPAL CITIES

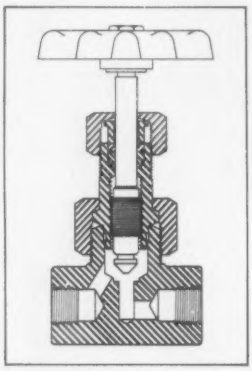
Circle 569 on Page 19

cone-rubber washer permits positive sealing so that changes in atmospheric conditions will not affect the setting. **Johanson Mfg. Corp.**, 400 Rockaway Valley Rd., Boonton, N. J.

Circle 774 on Page 19

### Hand Valve

**has positive shutoff and freedom from galling**



Floating Cone ¼-in. hand valve is recommended for liquid or gas service on meter manifolds, seal chambers, hydraulic equipment, and similar applications. Valve is available in five variations of globe and angle types, accommodating line pressures to 3000 psi. Stem of cone valve terminates in a socket which holds the knuckle of a conical-shape plug. With plug firmly seated at closure, stem is free to rotate on the knuckle surface; no amount of further tightening will score the polished cone. Stem is Type 416 stainless steel; packing gland is Type 303 stainless; body, bonnet, and union nut are heavy-duty steel. Teflon ring packing keeps friction to a minimum and requires no lubrication. Bonnet is precision aligned with body for accurate seating of plug. Bonnet seat checks rise of stem and provides seal to permit repacking at full line pressure. **Foxboro Co.**, Foxboro, Mass.

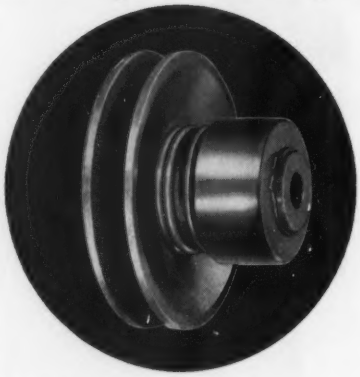
Circle 775 on Page 19

### Force Control Switches

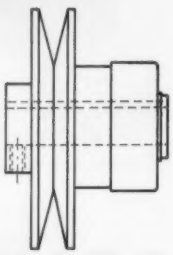
**are furnished in tensile and compression types**

Automatic starting and stopping of motors, activating of equipment in sequence, tripping of relays, and

**NEW! A Line of Vari-Speed Pulleys**



Specially Designed for Competitively Priced Equipment



The price is right. Quality is in keeping with Lovejoy's standards. You'll get more pulley per unit cost than any other in a comparable price range.

**Features include:**

- **High ratio for small face diameter**
- **Smooth pulley faces—no interlocking fingers**
- **Infinitely variable over full speed range**
- **Compact, lightweight construction**

Sizes range from fractional to 1 hp., ratios to 2.8 to 1.

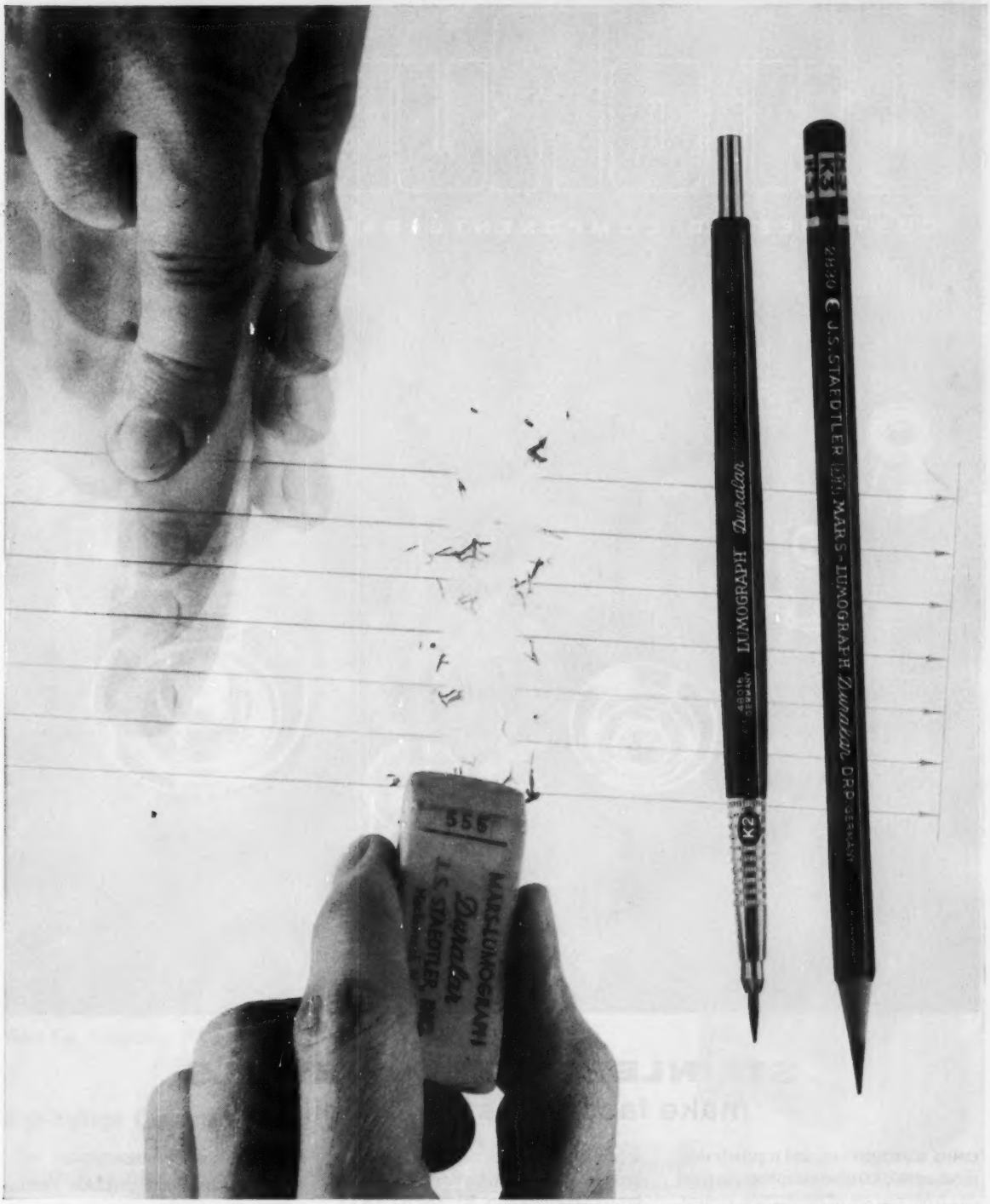
*Request OEM Series Bulletin 701. Ask for recommendations on your application.*




Lovejoy
*First Name In Vari-Speed*

**LOVEJOY FLEXIBLE COUPLING CO.**
4019 W. LAKE ST. • CHICAGO 44, ILL.

Circle 570 on Page 19




Mars products are available at better engineering and drafting material suppliers everywhere

# *Duralar:*

## WON'T SMEAR ON MYLAR - ERASES ON MYLAR

Specifically designed to work perfectly on matte-surface drafting film of Mylar®, Duralar is the newest in the complete line of Mars fine drafting products. All are imported from West Germany and are made to meet the highest professional standards. Shown: Mars-Lumograph Duralar pencil and lead—available in five special degrees, K1 to K5; Mars-Duralar Technico with adjustable Duralar degree indicator; Duralar eraser.

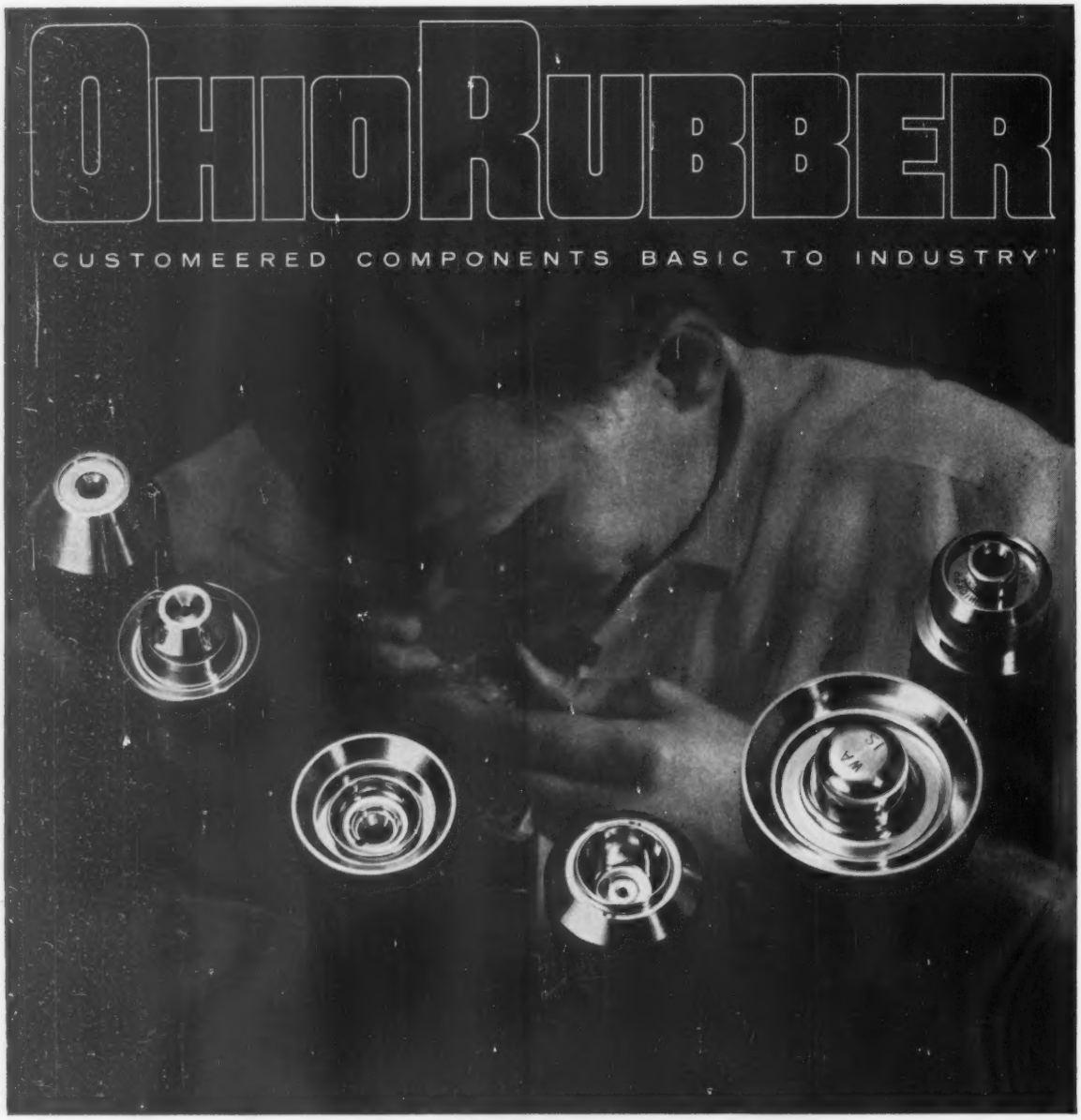
® T.M. for duPONT's Polyester film.

*the pencil that's as good as it looks* **MARS**

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

# OHIO RUBBER

CUSTOMEERED COMPONENTS BASIC TO INDUSTRY"



## STAINLESS STEEL JEWELS
### make facsimiles by the million!

**OHIO RUBBER** can, and regularly does produce 100,000 *identical* rubber parts per day from one set of production tooling. The jewel-like precision of the self registering molds shown above–actual size–is a key factor in ORCO's high speed, high accuracy, continuous molding process.

**AUTOMATIC INTEGRATION** of processing steps which are usually handled separately eliminates variables–provides precise control for achieving the ultimate in product uniformity. RUBBER PARTS up to 1½″ in diameter and 1″ in thickness produced by this process are distinguished by uniformity, minimum flash and precision tolerance of ± .003″.

**QUANTITY REQUIREMENTS** involving not less than 500,000 parts proves best for this new process.

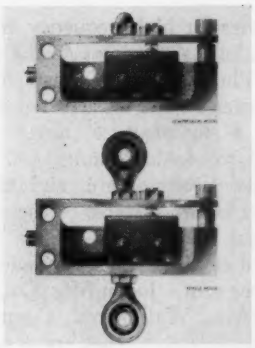
"**DO YOU** use small precision molded rubber parts by the million?", if so, the full story of ORCO "CUSTOMEERED" Continuous Molding is yours via free Bulletin CM-100. Send for your copy today to see how custom molded, precision rubber parts can be produced in volume—at less cost. MP-160

ORCO

THE OHIO RUBBER COMPANY

General Office • WILLOUGHBY, OHIO • WHitehall 2-0500

A DIVISION OF THE EAGLE PICHER COMPANY



registering of warning sounds or visual signals are typical of the many applications of subminiature force-control switches. Three different capacities are offered in the subminiature line: 0-5, 0-30, and 0-100 lb. These can be set to operate at any desired point within their respective ranges. **W. C. Dillon & Co. Inc.**, 14620 Keswick St., Van Nuys, Calif.

*Circle 776 on Page 19*

## *Stainless-Steel Strands*

**are silver plated**

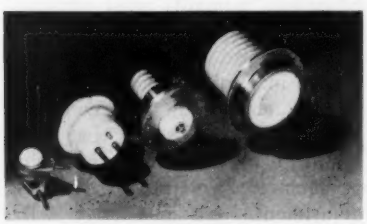
Silver-plated stainless-steel strands are available for use as strength members in stranded conductors. Because of its high tensile strength, stainless-steel strands are desirable as reinforcing members in stranded conductors. Nonsolderability of stainless steel, however, is a problem. With new process for silver plating stainless steel strength member can now be soldered with an adherence equal to plated-copper strands. **Ossining Div., Hudson Wire Co.**, Ossining, N. Y.

*Circle 777 on Page 19*

## *High-Voltage Connectors*

**for temperatures from −100 to +400 F**

New molding process that hermetically seals Teflon into a metal shell produces high-voltage lead-through

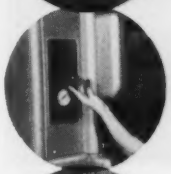



# *The Reproduction Machine That Goes Beyond The Call of Duty!*

The Revolute Comet—finest in the Revolute line—not only gives you a fast mechanical speed, up to 125 fpm, but all the important *extras* that help convert speed to actual production of top quality prints! Its unique air knife-suction separator assures efficient separation even at highest speeds. Its perforated roller developer section—a Paragon-Revolute exclusive—provides positive one-pass development at any speed, cuts ammonia consumption ¼ to ½ over other designs. Add to these a powerful 7500 watt lamp, reducible by degrees to approximately 50%, precision machined cast aluminum framework, a host of operator conveniences, and you have a whiteprinter that goes far beyond the expected to give you the highest quality and quantity reproduction possible! The Comet comes in 42″ or 54″ printing width . . . choice of 100 or 150 watt/in mercury arc lamp. For proof of performance and economy beyond the call of duty, mail the coupon below.



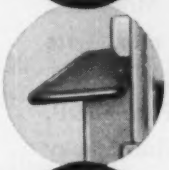
**Starting with the Comet's Micro-Start Button**, the operator finds an array of conveniences right at the finger-tips.



**Print Delivery Lever** is within easy reach of operator's normal position, directs prints to front or rear delivery tray.



**Lamp Intensity Control Knob** reduces lamp intensity by degrees to 50%, provides wide flexibility for handling different reproduction materials.



**Oak Feedboard** (22½″x75″) is slanted to just the right degree to aid operator's production, and to reduce fatigue.



**Comet's Safety Device** prevents the entering of foreign objects at feeding point by throwing Comet out of gear.



PARAGON REVOLUTE

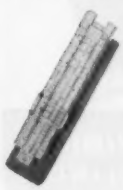
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BRUNING

77 South Avenue, Rochester 4, N.Y.

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**When You Attend a Demonstration of the Comet!**



We would like to present you this professional Bruning pocket slide rule at the time you attend a demonstration of the Comet. This quality, all-plastic slide rule contains 9 basic slide rule scales, comes with genuine leather sheath.

**Paragon-Revolute Advertising Department, Dept. P9-W**
**1800 Central Rd., Mt. Prospect, Illinois**

☐ Please send me more information about the Comet.

☐ Please arrange for your representative to contact me about a demonstration.

**Name**_____ **Title**_____

**Company**_____

**Address**_____

**City**_____ **County**_____ **State**_____



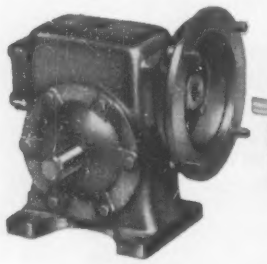

*Circle 573 on Page 19*

# 956

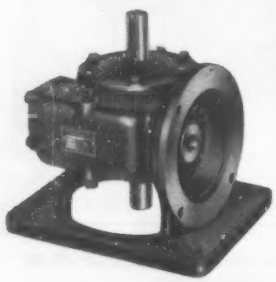
different
motorized
speed reducers

## *available from stock*

Yes! 956 different combinations of Perfection Motorized Worm Gear Speed Reducers are available for immediate delivery, *from stock.* Ratios range from 5 to 1 to 60 to 1, in capacities from 1/6 H.P. to 5 H.P. Perfection "C" Flange Reducers may be ordered complete with motor or without motor, to be used with a motor *of your own choice.*



Flanged motor reducers offer the maximum in compactness, rigidity and adaptability. Through the use of standard NEMA face mounted motors, complete interchangeability between motors is provided. Motor maintenance is possible without disturbing the drive and reducer. Motor assembly is fast and positive with no alignment problems.



**Write for your free copy of our new 28 page catalog containing illustrations, charts and tables to help you choose the right Reducer for your particular application. Ask for Bulletin No. M-140.**

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PERFECTION GEAR COMPANY, HARVEY, ILLINOIS


*Circle 574 on Page 19*



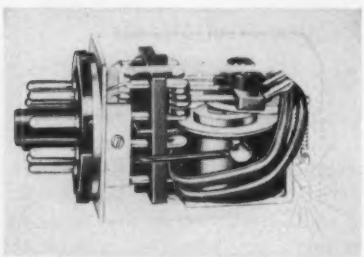
bushings for high-frequency service. Gases, oils, and vapors do not penetrate Fluormetic Hi-Voltage connectors even when cycled repeatedly over a temperature range from −100 to +400 F under 100 psig. Excellent corona, arc, and ratings to 300 kv are features of these connectors. Connectors operate under rugged conditions when humidity is 100 per cent. **Joclin Mfg. Co.,** Lufbery Ave., Wallingford, Conn.

*Circle 778 on Page 19*

### *Plug-In Relay*

**incorporates built-in miniature neon lamp**

Series 1210-N plug-in relay has a miniature neon lamp connected across its coil terminals. Lamp lights when coil is energized; should it remain unlit with coil energized, a circuit fault would be indicated. Principal advantage of the light is



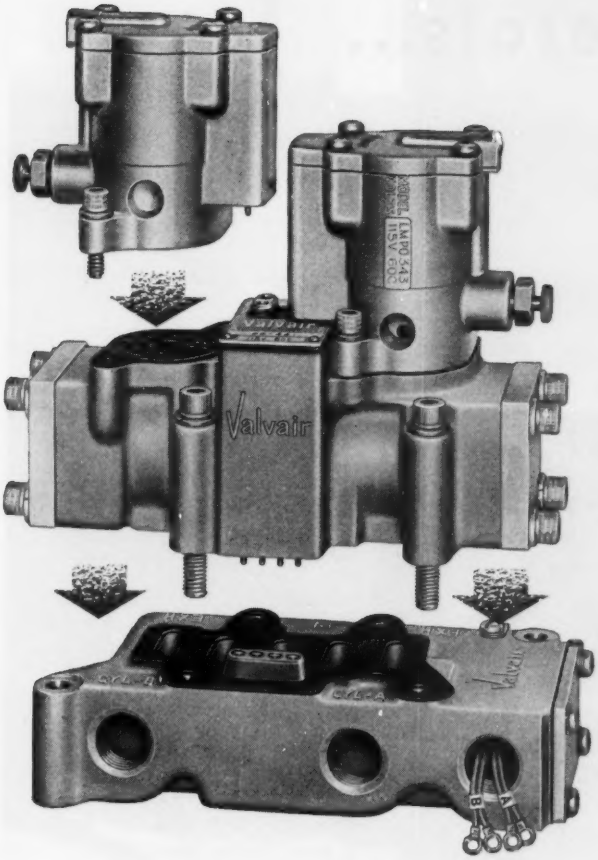
that it precludes the use of a circuit tester. Relay is available with 8-pin octal plug for DPDT and 11-pin plug for 3PDT. Contacts are rated 8 amp at 115 v ac, 60 cycles, noninductive load. Size of unit is 2 22/32 x 1⅜ x 1⅜ in. **Guardian Electric Mfg. Co.,** 1550 W. Carroll Ave., Chicago 7, Ill.

*Circle 779 on Page 19*

### *Miniature Potentiometer*

**wafer-shaped units are humidity-proof**

Model 3250 precision adjustment potentiometers feature wafer configuration, humidity-proof construction, extra-high reliability, and subminiature size. Measuring ½ x ½ x 3/16 in., units incorporate an exclusive clutch design, combined with positive end-stops, that eliminate the hazard of open circuiting or damage to internal parts during adjustment. Resistance range is 100




# VALVAIR® ½" NPT PLUG-IN VALVES

**MODEL PD-441 shown.** 4-way single or double pilot-operated types, for sub-base or manifold mounting. Aluminum and stainless steel components assure multi-million cycle dependability. Interchangeable pilots, with coils guaranteed against burn-out for life of valve, fit any plug-in Speed King. Coils for ac or dc, any voltage . . . 35 — 200 psi range . . . integral junction box . . . optional manual over-ride, common or separate exhaust ports, sub-base connected external pilot supply . . . ¾ in. exhaust ports, ½ or ¾ in. inlet and cylinder ports . . . valve meets JIC standards.

Based on the service-proved design principle of the Speed King ¼ in. plug-in Valvair's ½ - ¾ in. plug-in valve series provides plug-in convenience and versatility to a wider range of control valve applications.

Electrical and pneumatic circuits are completed automatically when valve and pilot are plugged in . . . bolted down. The result — cost-cutting reduction of original installation and maintenance time. All power connections are made permanently in sub-base or manifold . . . there's no need to disturb piping or wiring for quick in-service maintenance.

What's more, advanced design shortens stroke . . . speeds response. Separate coded (4-wire) circuits on double solenoid models meet JIC requirements. Flow area through valve and sub-base equals that of full ½ in. pipe.

Whether your control valve applications are on the drawing board or now in service, it'll pay you to investigate the advantages of Valvair plug-in design. A call to your near-by Valvair field office will bring prompt application engineering recommendations.

For more information, write for Bulletin SPL. Address Dept. MD-960, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio

**Bellows-Valvair**

*The Bellows Co. • Valvair Corp. Akron 9, Ohio*

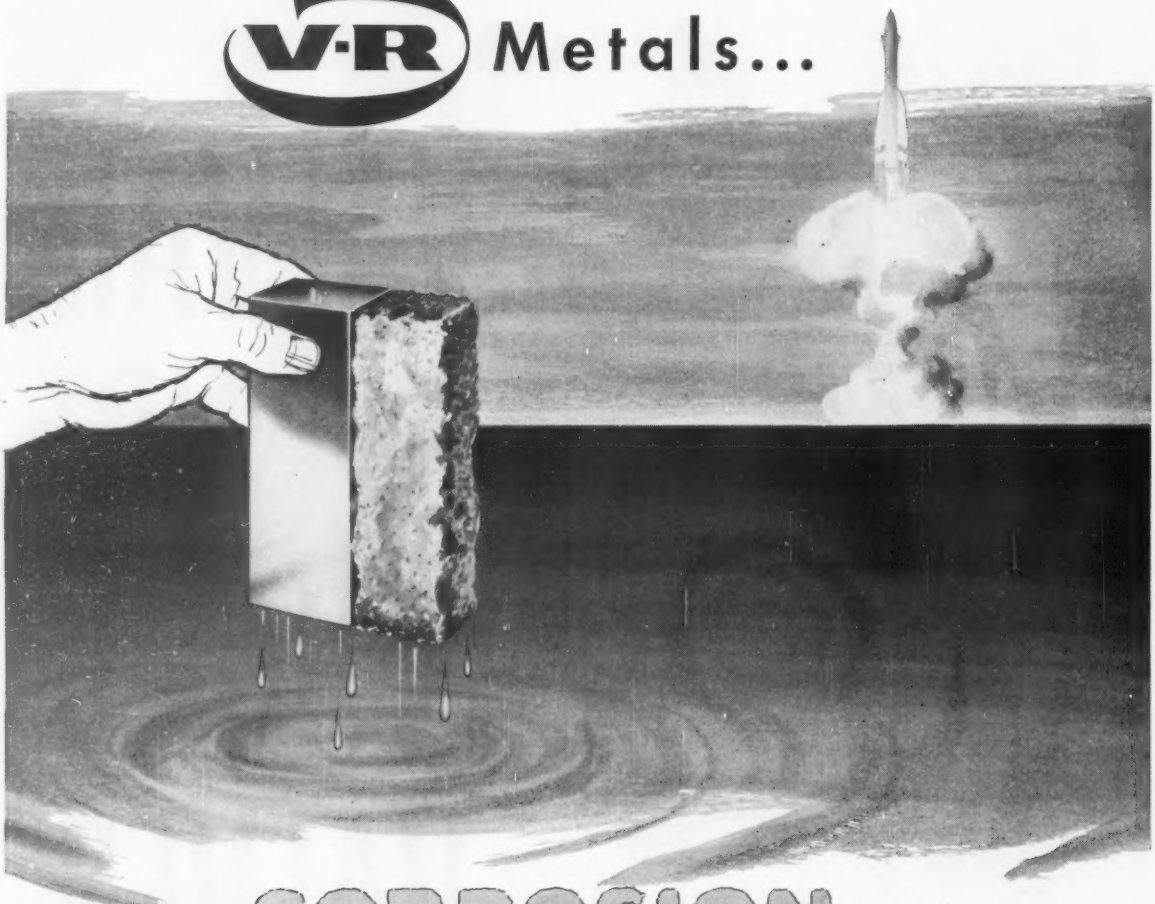
DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

8098-3



Circle 575 on Page 19

# V-R Metals...

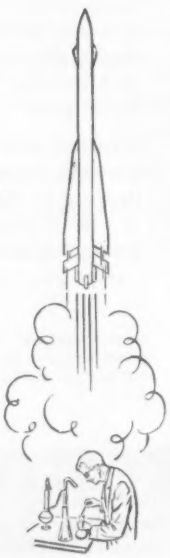


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Vascoloy-Ramet, pioneering manufacturer of refractory metals, is making a substantial contribution to today's advancing metallic age. V-R is creating and developing special metals with exceptional characteristics to meet the ever-changing demands of industry. Thirty years of V-R research, engineering, and manufacturing experience have produced the metallurgical knowledge built into all V-R products. This same experience and knowledge is working full time to meet the needs of tomorrow.

A-798



Vascoloy-Ramet creates metals that are impervious to corrosion. V-R also creates metals that possess amazing stability at extreme temperatures, high rigidity under load, extremely low coefficients of expansion, ultra-high density and controlled uniformity.

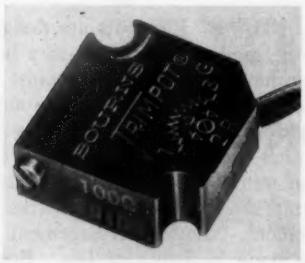
Yes, many of today's metal requirements are met by Vascoloy-Ramet. V-R designs these sintered and alloyed materials to fill your metal requirements. Many engineers are utilizing V-R assistance for metal design assurance.

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to 50,000 ohms; power rating is 1 w at 70 C; and operating temperature range is −65 to 175 C. The 25-turn adjustment is accomplished quickly with a standard screwdriver. **Bourns Inc.**, 6135 Magnolia Ave., Riverside, Calif.

*Circle 780 on Page 19*

### Insulating Disc

**is now available in several sizes**

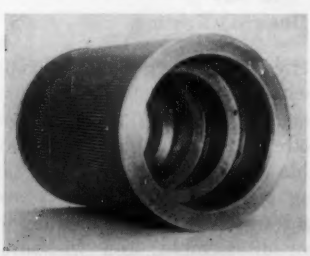
Subminiature insulating disc has diameters from 0.020 to 0.500 in., in any graduants. Thicknesses range from 0.008 to 0.050 in. Part can be applied to diode assemblies and rectifier insulation, and is suitable for high-temperature applications in any type electronic part. Subminiature ceramic part is alumina oxide, metallized on either or both sides with molybdenum manganese and plated with nickel, copper, or gold, depending upon the application. Prototypes or samples of the disc are available. **Mitronics Inc.**, 1290 Central Ave., Hillside, N. J.

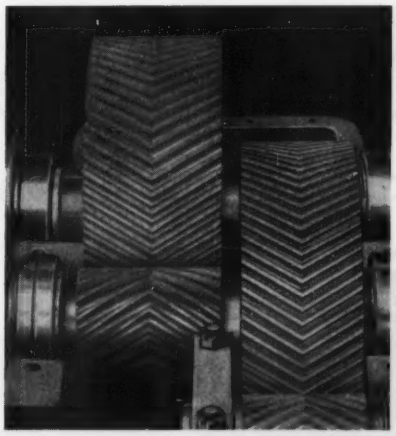
*Circle 781 on Page 19*

### Filter Elements

**are single-element 10 and 20-micron units**

Single-element 10 and 20-micron filters handle large flows to 100 gpm. The 20-micron unit handles 100 gpm at 1 psi; 10-micron unit handles 100 gpm at 2½ psi, based



When you come to Farrel for a gear unit you get the benefit of broad selectivity in types, capacities, speeds, and ratios. This enables you to select the unit which meets your needs exactly.

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Standard speed increaser (See bulletin 451)



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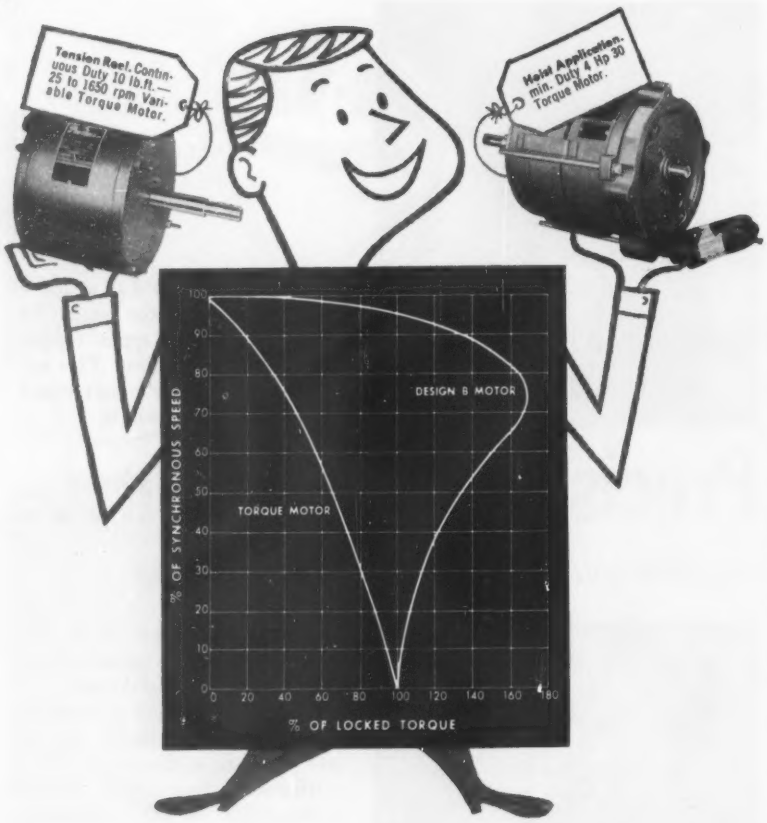
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AGMA

FB-1197




*Circle 577 on Page 19*




*Comparative Speed-Torque Curves of NEMA Design B Motor and Typical Torque Motor.* The speed torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.

# When holding or resisting force is needed . . . TORQUE MOTORS from PEERLESS ELECTRIC

Motors for tension reel, hoist or those with brake, more often than not call for a special design. That makes Peerless one of your best sources. We custom build torque motors . . . will work with you to produce the *one* motor that powers your product for peak performance.

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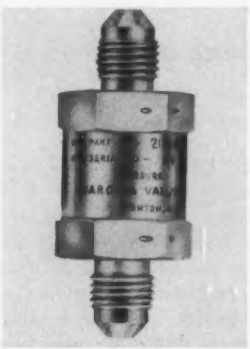


on 150 ssu. Elements are designed to be used on a full flow in a housing having a working-pressure capacity of 125 psi. They are amply rigid to withstand pressure surges which may build up faster than the automatic bypass can react to limit the pressure drop across the element. Element replacement can be made in 5 min or less. **Rosaen Co.**, 1776 E. Nine Mile Rd., Hazel Park, Mich.

*Circle 782 on Page 19*

## Check Valve

**provides fast response and positive sealing**



Designed for use with hydraulic fluids, inert gases, and hydrogen peroxide, check valve with Viton-A, Buna-N, or nylon seat provides fast response and positive sealing. Standard CVM4C model has an operating pressure of 3000 psig, with a high-pressure version available to 4500 psig. All models operate at temperatures from −65 +160 F. Male ports, per AND 10056-4, are for connection with ¼-in. tubing or hose. Over-all length is 2.280 in., diameter, 0.812 in., weight, 1.2 oz. **Marotta Valve Corp.**, Boonton, N. J.

*Circle 783 on Page 19*

## Switching Element

**now has internal lighting**

Series 7300 Digiswitch, a compact switching element for converting visual decimal settings to computer-code electrical outputs, is now available with internal lighting. Lighting subassembly is easily removed and installed in the module without disassembly, and without dis-

# jamesbury

## "Double-Seal"™ BALL VALVES*

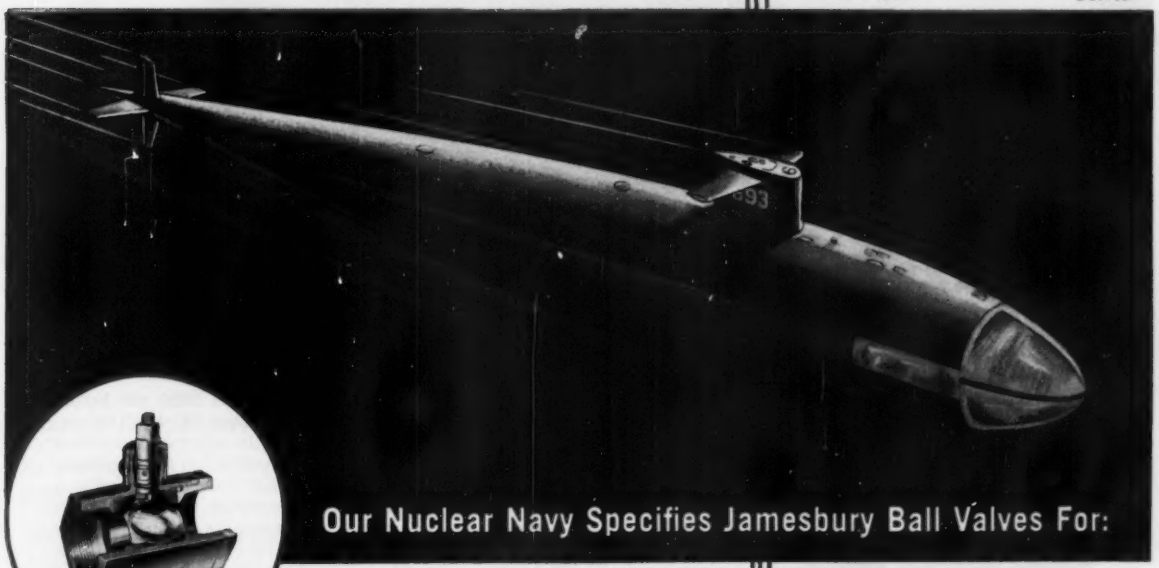
## HELPING TO BUILD THE NUCLEAR NAVY

19 Nuclear Submarines in operation or under construction will carry Jamesbury "Double-Seal" Ball Valves.

The Jamesbury "Double-Seal" Ball Valve principle solved vital operational problems for our nuclear navy and is today a major factor in the building of our atomic undersea power.

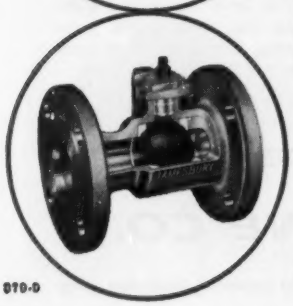
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| PERMIT | SSN594 |
| PLUNGER | SSN595 |
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- corrosion resistance

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This Sandusky Centrifugal Casting—one of four produced for Westinghouse Atomic Equipment Department—meets radiographic, intergranular corrosion, and all other rigorous chemical and physical tests.



# ONE SANDUSKY CENTRIFUGAL CASTING ...makes 4 giant stator shells

*Specified by Westinghouse for 4 canned motor pumps soon to be integral parts of reactor system in Yankee Atomic Electric Plant in Rowe, Massachusetts*

One king-size 17-ton Sandusky casting supplied the main motor bodies (stator shells) for the four pumps being built by Westinghouse, each to handle 23,600 g.p.m. of pressurized water through the reactor core.

The 25-foot-long Sandusky casting was centrifugally spun of a modified CF-8 (Type 304 L) stainless steel, then machined by Sandusky to a 3″ wall thickness, 31½″ on the O.D. This huge casting was hydrostatically tested to 3800 psi before being sectioned into four 68″ lengths.

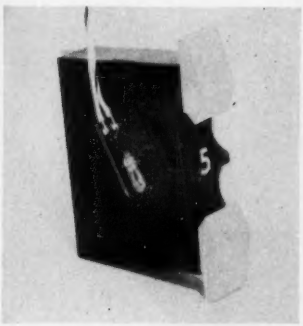
These stator shells represent another *new and exacting application* for Sandusky Centrifugal Castings—which may offer a practical and economical answer to *your* cylindrical requirements also. They are available in diameters from 7″ to 54″—in lengths up to 33 feet—in heat- and corrosion-resistant stainless, carbon and low-alloy steels and a wide range of copper-base and nickel-base alloys.

Let us show you how Sandusky Centrifugal Castings can help solve your cylindrical problems. Write to us at Sandusky, Ohio.

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**FOUNDRY & MACHINE CO.**

SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys



turbing the switch mechanism. Standard lighting assembly uses 30-in. leads, operates at 1.5 v, and has normal operating life of 2500 hr. **Digitran Co.**, 660 S. Arroyo Parkway, Pasadena, Calif.

*Circle 784 on Page 19*

### *Flame-Retardant Laminate*

**for printed-circuit use**

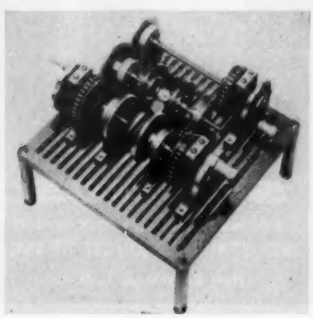
Flame-retardant industrial laminated plastic, Grade FR-4, is a glass-base laminated plastic with an epoxy-resin binder. It is available specifically for printed-circuit and general electronic-component use. Qualities include high mechanical strength at room temperature, and good dielectric loss and dielectric breakdown properties under both dry and humid conditions. Grades FR-4 can be furnished with copper cladding on one or both sides, in standard foil thicknesses. It is available in sheets, rods, and tubes. **Synthane Corp.**, Oaks, Pa.

*Circle 785 on Page 19*

### *Miniature Components*

**for prototype or production use**

Suitable for use in applications embodying space and weight limitations, miniature components are available in Precision 1, 2, and 3




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**ROCKFORD CLUTCHES**

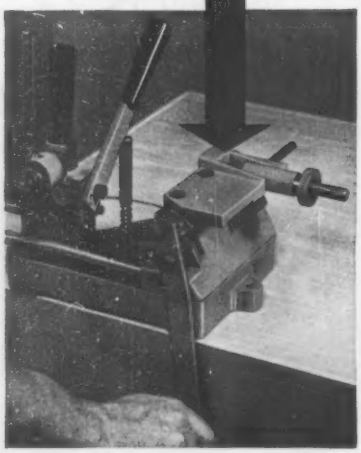
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*Circle 581 on Page 19*

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**DI-ACRO* Spring Winder**

This unique machine eliminates costly special spring orders, saves valuable waiting time. Winds compression and extension springs to 1½" O.D. Handles round, flat and rectangular wire to ¼" dimension. Note exclusive features in the hand operated Di-Acro Spring Winder which assure accurate tension and fast operation without special experience or skill.

new **TENSION CONTROL**—Simply adjust to desired tension—the control keeps it uniform, for winding one spring or hundreds, and releases when each spring is wound.

new **WIRE CUT-OFF**—After spring is wound, release tension and use cut-off lever to quickly cut end of spring to desired length.

new **CAM LOCK**—Simply feed wire under cam, turn handle and wire is securely locked to arbor while spring is wound. No threading required.

**FREE ENGINEERING SERVICE**



Send us your spring forming problems—samples or dimension sketches—together with sufficient test material, and let us wind some sample springs for you free of charge. No obligation. Quick Facts Folder gives details on all Di-Acro Precision Machines. Consult the yellow pages of your phone book under Machinery, Machine Tools for the name of your Di-Acro distributor or write:

*pronounced Die-ock-ro

di-acro PRECISION METALWORKING MACHINES

**O'NEIL-IRWIN MFG. CO.**
**416 8th Ave.**
**Lake City, Minn.**

*Circle 582 on Page 19*

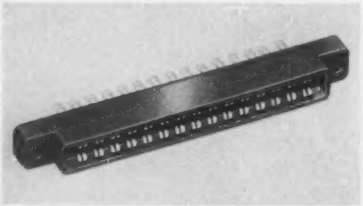


tolerances. Conforming to military specifications, the line, in 5/64, 3/32, and ⅛-in. shaft sizes, includes gears, shafts, differentials, ball bearings, couplings, collars, spacers, gear plates, and other components needed for prototype or production use. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y.

*Circle 786 on Page 19*

### *Printed-Circuit Connectors*

**have contacts of beryllium copper**



Series 600-120 printed-circuit Continental connectors incorporate beryllium-copper contacts. Units have dual terminations and bifurcated contacts for 1/16-in. printed-circuit board or tape cable. They are available in 6, 10, 15, 18, 22, 28, 43, 48, 58, and 105 dual-contact sizes, and in a choice of three mounting styles and three wiring styles. Series meets or exceeds MIL-C-21097A specifications. **Electronics Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y.

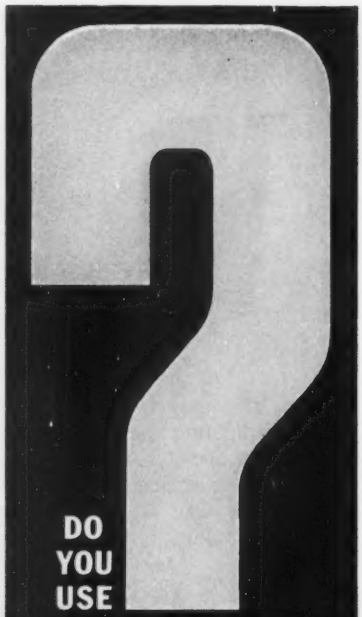
*Circle 787 on Page 19*

### *Mica Capacitor*

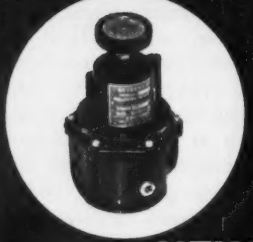
**is 5/16 in. long and ¼ in. wide**

Subminiature DM-10 dipped silvered mica capacitor is approximately 5/16 in. long, ¼ in. wide, and ⅛ in. thick. It is made with



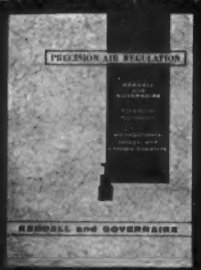


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Catalog gives performance and other data on 18 models of precision pneumatic pressure regulators. (pipe sizes ¼" to ¾" NPT)



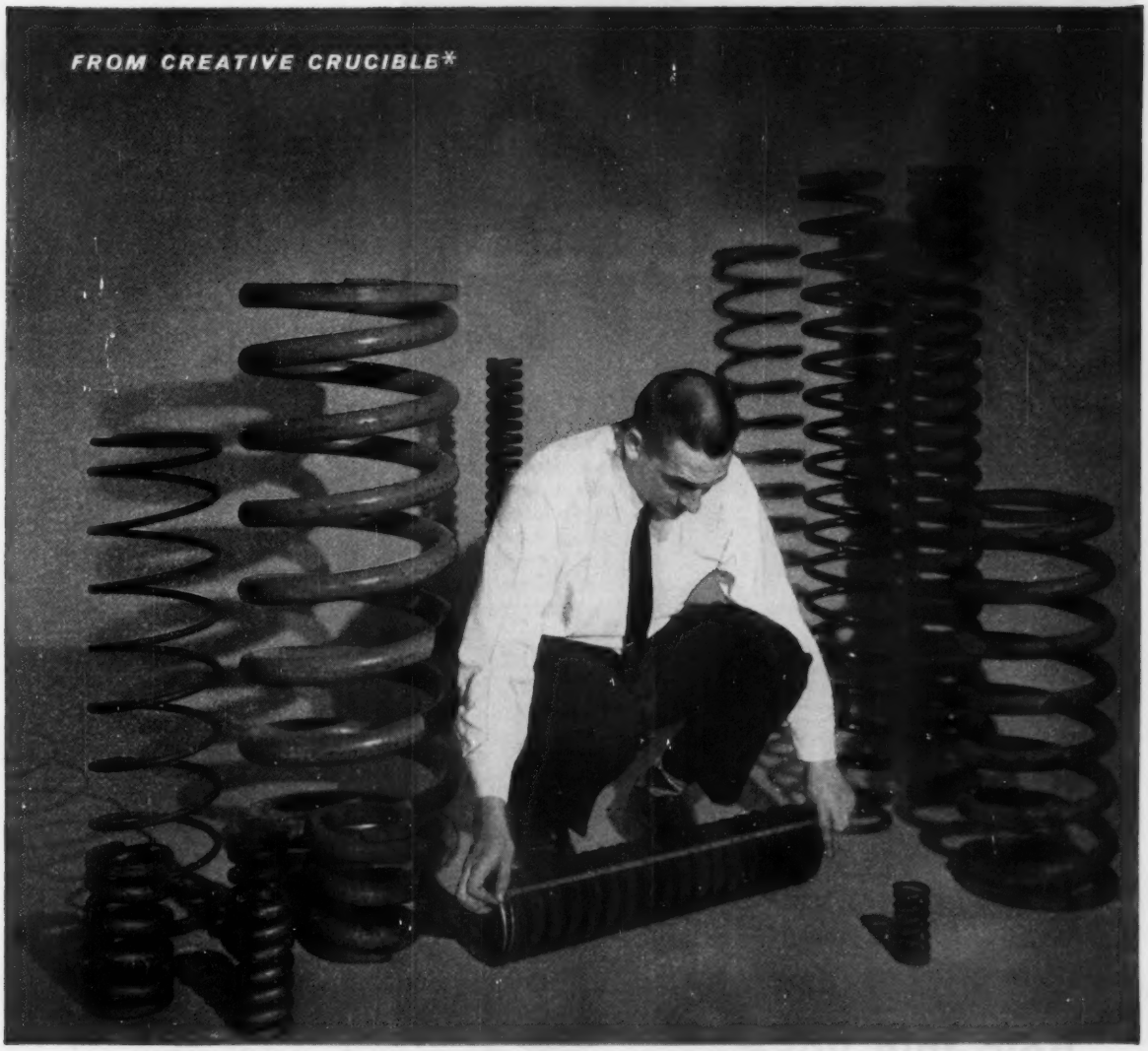

**STRATOS®**

A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

**INDUSTRIAL PRODUCTS BRANCH**

West Babylon, L. I., N. Y.

*Circle 583 on Page 19*




# All of these fatigue-resistant springs can bear heavy loads longer than conventional springs

Size for size, any one of these heavy-duty, hot-wound springs will withstand repeated stressing by a heavy load for a longer period of time than a conventional spring—compression, tension or torsion!

High intensity shot peening accounts for each of the springs' increased endurance. Shot peening imposes a compressive stress on the surface that offsets stresses set up in service. It also "conditions" the surface and eliminates stress concentration points that could lead to premature failure in a conventional spring.

**Design Handbook On Coil Springs**

But see for yourself how shot peening, combined with Crucible metallurgy from ore to finished spring, makes springs stronger—to last longer. Send for the *Heavy Duty Coil Springs* handbook. Write: *Crucible Steel Company of America, Spring Division, Dept. GI07, McCandless Ave., Pittsburgh 1, Pa.*

***HEAVY DUTY HOT-WOUND COIL SPRINGS**—Crucible makes fatigue-resistant and conventional springs of carbon, alloy, and specialty steels in a wide variety of treatments, from ½" bar size up. Both types are now being used in countless applications in missile launching equipment, farm implements, mining equipment and industrial conveyors.

**CRUCIBLE HEAVY-DUTY COIL SPRINGS**


Circle 584 on Page 19

Stearns electro-magnetic
DISC BRAKES
(THE CHOICE OF LEADING MOTOR MANUFACTURERS)




This Voss Leveler, installed at Inland Steel's Indiana Harbor Works—designed for hot-rolled plate up to 74-in. wide by 40-ft. long — from 3/16 to 1-in. thick . . . uses 4 of these Stearns motor-mounted, Style "H" Brakes.

...help this Voss Leveler flatten up to 1000 tons per turn — speeds to 282 fpm

Just as *Voss* solves almost any metals-leveling problem at high production speeds—with accuracy and flatness that in many cases equals or exceeds stretcher-level flatness . . . so *Stearns* has, for over 40 years, solved the problems of large, multiple disc Brakes (and Clutches) for the steel industry, cement industry, and other heavy-industry machinery . . . where their long, efficient life — ease of installation and maintenance have been *on-the-job-proved.*

*For Superior Performance on ANY Machine . . . Specify Stearns!*

*For solutions to YOUR Brake and Clutch problems, call the Stearns Representative in your vicinity. Or write, stating your specific requirements, directly to . . .*

Stearns ELECTRIC CORPORATION
120 North Broadway, Milwaukee 2, Wis.
Phone: BRoadway 2-1100

THE COMPLETE LINE OF CLUTCHES . . . BRAKES . . . CLUTCH-BRAKES



parallel leads for versatility, and is encased in phenolic as a protection against physical damage and moisture penetration. At a working voltage of 100 v dc, capacity range of the unit is 1-360 mmf; at 300 v dc, capacity range is 1-300 mmf; at 500 v dc, capacity range is 1-250 mmf. Operating temperature is to 150 C. **Electro Motive Mfg. Co. Inc.**, Willimantic, Conn.

*Circle 788 on Page 19*

## Adjustable-Speed Drive

**is compact and lightweight**

Fractional-horsepower Speed-Trol has the shortest over-all dimension and is up to 15 per cent lighter than comparable units. Speed ranges from 4660 to 1.2 rpm with up to 10:1 variation are offered



in 1/4, 1/2, and 3/4-hp ratings. Large pulley diameters assure a cool-running, long-lasting belt. Electrical characteristics include single and three phase, and enclosures include dripproof, totally enclosed, and explosionproof. Unit can be foot-mounted in any position or can be furnished with face-mounting bracket. It is available with right angle and helical gears. **Sterling Electric Motor Inc.**, 5401 Telegraph Rd., Los Angeles 22, Calif.

*Circle 789 on Page 19*

## Meter Relays

**have external magnet meter movement**

Front-adjustable, 4 1/2-in. meter relays, Model 29XA, have a dual-adjust contact arrangement and an external magnet meter movement. Voltage and current rating for adjustable contacts is 500 mw, 5-15 v dc on resistive or diode-protected inductive loads. Mechanical adjust-



*Circle 585 on Page 19*

# Some Ideas

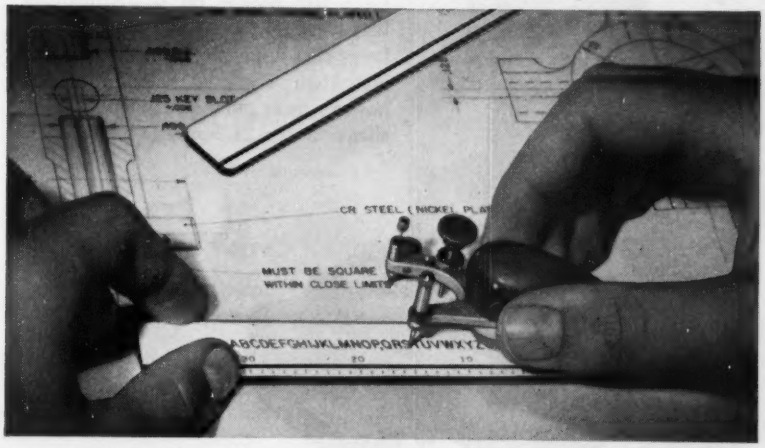
K&E

for your file of practical information on drafting and reproduction... from

**KEUFFEL & ESSER CO.**

When it comes to lettering—plain or fancy – professionals the world over turn to LEROY® Equipment by K&E. In drafting rooms, art departments – not to mention schools, business offices, churches, clubs, hospitals – LEROY has become almost as necessary as pencil and paper.

Truly, there's no magic about LEROY – just a beautifully simple idea, translated into products which reflect the highest manufacturing skill and imagination. Not easy, we grant you . . . but not magic.




However, to keep the LEROY line constantly up to the changing requirements of the times – that *does* require a wizard. Fortunately, we have just such a gentleman firmly settled on the K&E payroll. And he begs that we report several of the more recent minor miracles of LEROY right here and now. So, in the famed standard, sans-serif lettering template, let's make with a little . . .

## abracadabra

**Templates**

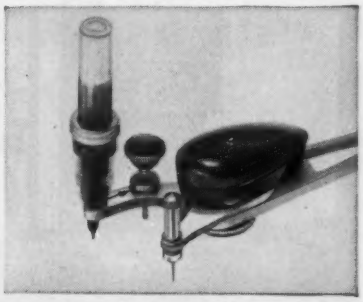
Every year sees new additions made to the already long list of LEROY templates. Case in point: the new electronic tube symbol templates for use in one of the most modern, fastest changing industries of them all. Also, there are foreign language templates (such as Russian and Greek), music templates, special designs, and a variety of handsome type faces (Caslon, Cartographic, Bernhardt Modern to name some newer additions).

The best advice we can give for keeping current on LEROY templates is to have the LEROY catalog on hand. (It just so happens that we recently put out a brand new edition of the catalog, and it's yours for the asking. See coupon at right.) Finally, of course, we should add that if you don't see what you need in our catalog, don't despair. We'll produce it, *custom-made*, to your design – as we have done for thousands of others.

**A "Built-In" Pencil Point**

The business of stopping work to put a sharp point on a lettering pencil is now largely over and done with, thanks to another new LEROY item. The point of the new LEROY "020" pencil never blunts or dulls – it's permanently sharp. And that, we submit, is a pretty sharp idea. The lead of this new pencil is an unvarying .020 inches in diameter, from one end to the other. All that's necessary to repoint is to advance the lead with a turn of the pencil shaft. No need to remove it from the scriber, by the way. This new pencil fits all LEROY scribers, and guarantees faster, smoother work. As to appearance – all lines drawn with the "020" are perfectly uniform, and of exactly the same density (a careful balance, chosen to give good wear without sacrificing print-making quality). You never saw pencil work look so good.





**The Pen With A "Built-In" Inkwell**

Here's your ticket to faster ink work with far fewer refills—K&E's new LEROY Reservoir Pen. You'll be amazed at the mileage you can get between refills with this newly perfected pen. Its refillable cartridge holds enough ink for many hours of smooth, uninterrupted lettering, thus eliminating the need for daily cleaning. The pen's cartridge is airtight – made of a non-porous, unbreakable, translucent material. The level of ink is always visible, and any non-solvent, waterproof India drawing ink can be used (for best results and quicker, easier filling we recommend the LEROY Lettering Ink-Cartridge #2950).

A tiny weighted needle inside the pen's feed tube assures a clear passage of ink from reservoir to point. Light vertical shaking of the pen activates this needle, removing any particles which may have settled in the tube when the pen was set aside. The needle also provides efficient cleansing action when you wash out the pen.

LEROY Reservoir Pens are furnished in seven sizes, from 00 to 5, for use with all LEROY scribers. Ideal for lettering work, the points glide easily over paper, cloth or film based surfaces, producing sharp, uniform lines that reproduce crisply.

**Order Your LEROY Catalog Now**

Other new additions and improvements – too numerous to go into here – are described in the new LEROY catalog. The coupon below brings your copy, free.

**KEUFFEL & ESSER CO., Dept. MD-9, Hoboken, N. J.**

Please send me the latest catalog on LEROY Lettering Equipment by K&E.

Name & Title_____

Company & Address_____

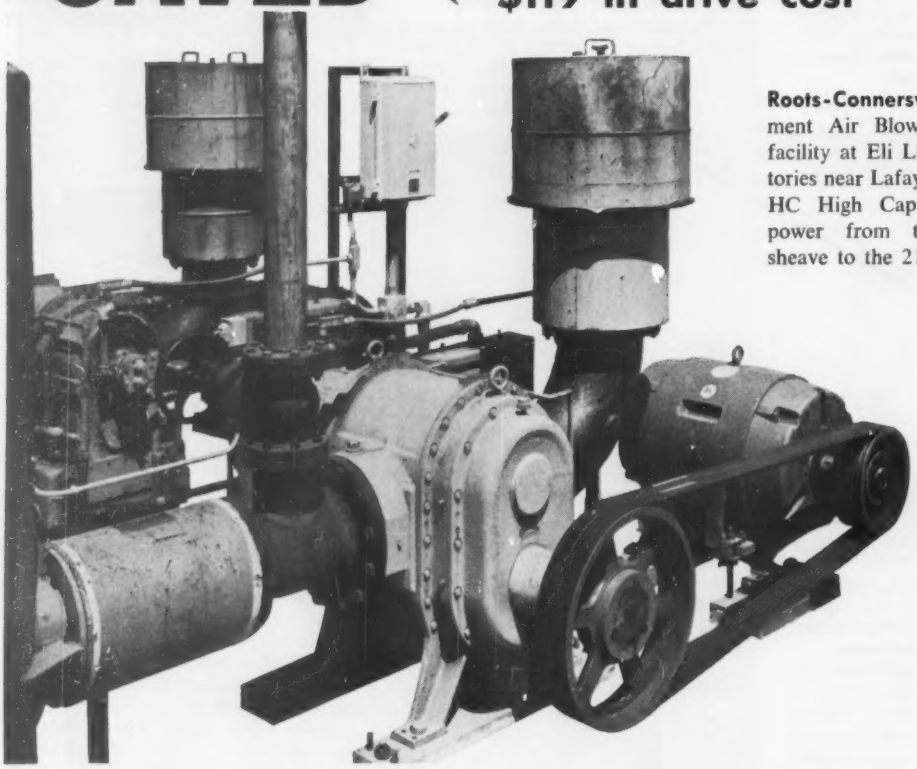
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Circle 586 on Page 19

# Gates High Capacity Drive on Blower for Eli Lilly

## SAVED { 6⅞" in face width
97 lbs. in drive weight
$119 in drive cost



**Roots-Connersville** Positive-Displacement Air Blower on waste-treatment facility at Eli Lilly Company's Laboratories near Lafayette, Indiana. Six Super HC High Capacity V-Belts transmit power from the 13.2-inch DriveR sheave to the 21.2-inch DriveN.

For each blower that Roots-Connersville supplied for the Lilly Laboratories at Lafayette, Indiana, original drive specifications called for 11-groove sheaves using standard belts.

Because 11-groove sheaves were special and time was short, the original drive specifications were re-examined. Could Gates Super High Capacity V-Belt Drives handle the installation better?

They could – and did. Instead of 11-groove drives, regular 6-groove Super HC Sheaves and Super High Capacity Belts were shipped from stock . . . arrived at the job overnight . . . saved the situation – as well as time, money, space and weight.

**For all users of multiple V-belt drives . . .**

Gates Super High Capacity V-Belts offer similar opportunities to save. These Super HC Drives pack the same hp capacity into smaller space – require fewer belts, smaller sheaves, shorter center distances. The helpful design handbook *"The Modern Way to Design Multiple V-Belt Drives"* is yours for the asking. Just ask your Gates Distributor, listed in the Yellow Pages in the nearest industrial center.

TPA538

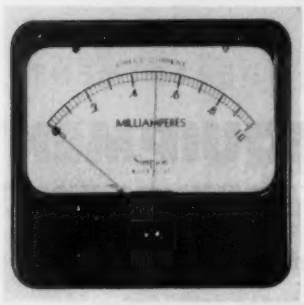
**The Gates Rubber Company,** Denver, Colorado
**Gates Rubber of Canada Ltd.,** Brantford, Ontario




Gates *World's Largest Maker of V-Belts*

# Gates Super HC HIGH CAPACITY V-Belt Drives

**same hp capacity in smaller "package"**



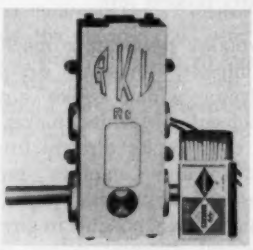

ment is to within 2 deg. Nonlocking contacts can be positioned along the instrument scale arc by means of an external, front-adjusted gear drive. **Simpson Electric Co.**, 5200 W. Kinzie St., Chicago 44, Ill.

*Circle 790 on Page 19*

## *Solenoid-Operated Valve*

**provides gas-tight shutoff under vacuum or pressure**

Solenoid-operated, pinch-type valve is used for metering, sampling, or on-off control in applications involving corrosive fluids, slurries, dry powder, or sanitary products. Capable of providing absolutely gas-tight shutoff under vacuum or pressure conditions, valve is made in sizes from 1/16 to 1 in. Series Rs valve consists of a rubber body that is pinched-closed by the spring-loaded solenoid mechanism. There are no moving parts in the fluid stream, and no seats, discs, or packing glands to leak. Simple design

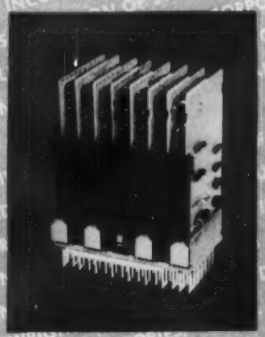



permits straight-through flow in either direction. Normally-closed, energized-to-open valve can be operated manually or from programmers, alarms, timers, or automatic sensing instruments. Standard valve body is pure gum rubber with a maximum pressure rating of 50 psig for the smallest size. **RKL Controls Inc.**, Hainesport Industrial Park, Hainesport, N. J.

*Circle 791 on Page 19*


# CONSOLIDATED

## CUSTOM MOLDING FOR "BLUE-CHIP" INDUSTRY



**For more than eighty years, Consolidated Molded Products Corporation has been a preferred source of high-quality plastics requirements for America's top-ranking companies.**

**Consolidated is a complete plastics product supplier, small or large parts, compression or injection, thermosets or thermoplastics.**

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CONSOLIDATED MOLDED PRODUCTS CORPORATION

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*Circle 588 on Page 19*

Wolverine

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Cost Less per Thousand Clamping Operations

Note These Important Features:

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8 STANDARD ACTION UNITS
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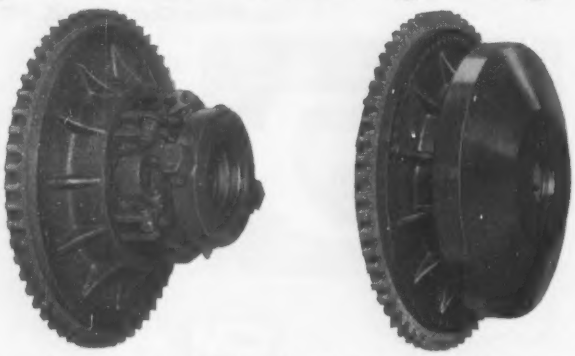
CQ-810

C-150

Circle 589 on Page 19



Make Your Choice Of Clutch While Your Equipment Is In The Design Stage . . .



You can have your machine equipped with either our Over-Center Friction Clutch (left) or our Air-Operated Clutch (right). Each has its advantages depending on the use of the equipment. These clutches come in a wide range of sizes and with gear tooth or Flex-Disc. All are high quality, dependable clutches having low power losses, low upkeep, and long life. Readily adjustable for lining wear. Send for bulletins 5009 (Over-Center), 5011 (Air-Operated), or 5012 briefing our entire line of industrial clutches.

INDUSTRIAL CLUTCH CORP.
Waukesha Wisconsin

Circle 590 on Page 19

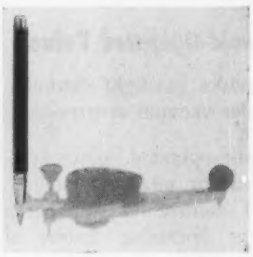

ENGINEERING DEPARTMENT

# EQUIPMENT

## Lettering Pencil

**assures uniform lines**

Leroy 020 lettering pencil produces uniform lines throughout an entire job without repointing. It is designed to operate with the Leroy Scriber. Uniformity of line width is assured by a new, thin lead with 0.020-in. diam point. Lead is advanced by turning pencil while it is in the scriber, permitting uninterrupted lettering. Pencil is furnished in a plastic case which also contains a lead dispenser and 24 refills. **Keuffel & Esser Co.**, Third & Adams Streets, Hoboken, N. J.

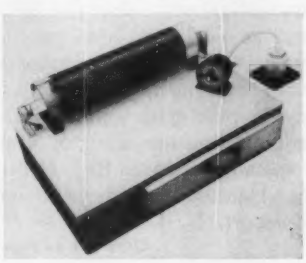


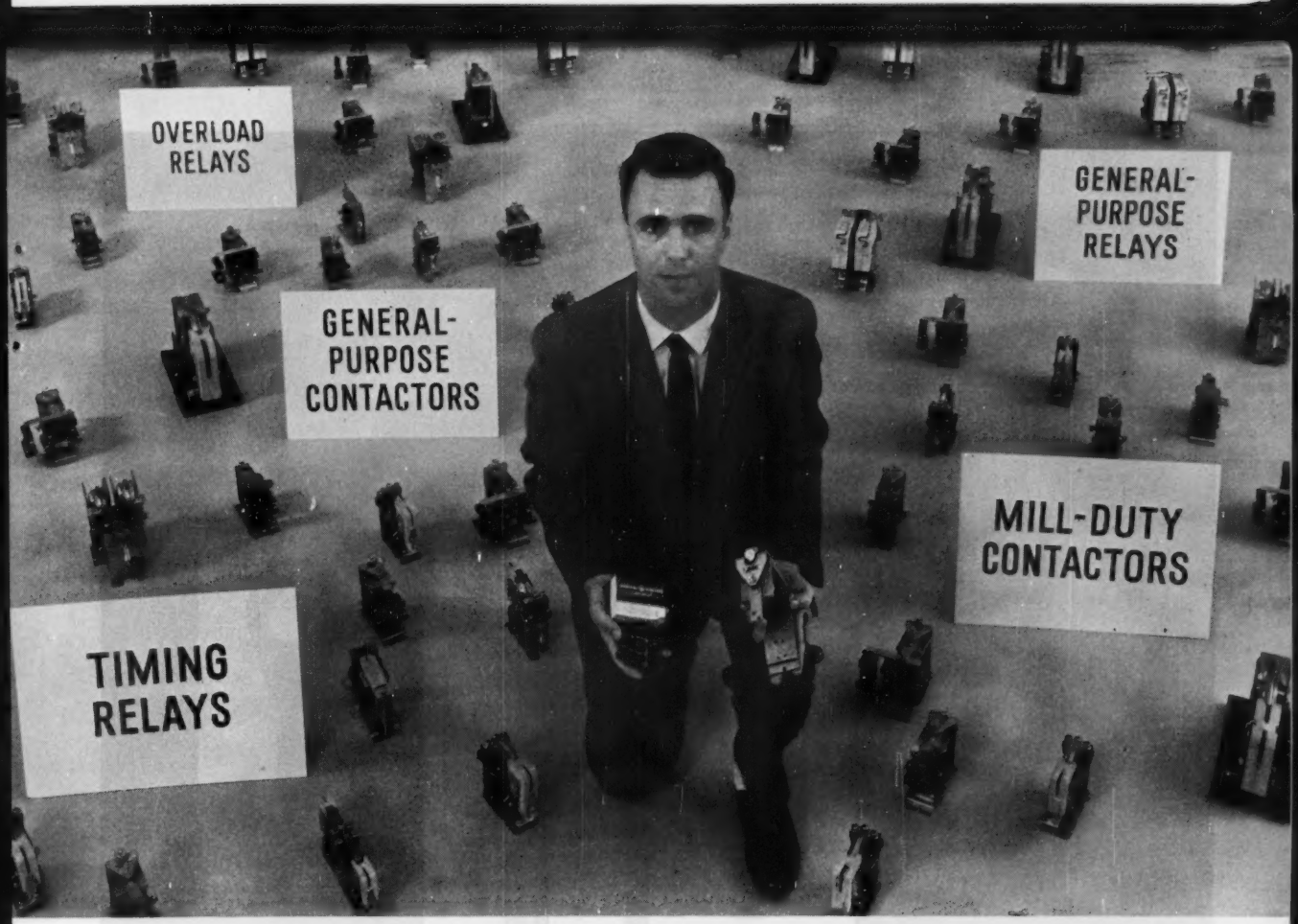
Circle 792 on Page 19

## Duplicating Machine

**is dry-process unit**

Copymaker duplicating machine is a complete, low-cost, dry-process duplicator which copies anything translucent. Machine makes accurate, clear copies directly from the original, and employs ordinary diazo-type dryprinting paper. Reproductions are possible in any color, or several different colors, in any size to 11 x 17 in. Copying operation can be done in daylight. Unit






## *GENERAL ELECTRIC DC CONTACTORS AND RELAYS*

# Over 100 devices – available when you need them

Now . . . you don't need to wait for delivery of a particular contactor or relay . . . or to carry a large inventory . . . just to be sure you have the correct device for a job. With General Electric's new d-c contactors and relays—featuring "building-block" design—you assemble the device you want . . . when you ***need*** it . . . from standard components right in your own plant. More than a hundred different devices can be assembled from a parts stock of as few as a dozen General Electric "building-block" components!

This amazing versatility means ***immediate availability*** of any General Electric device. A "universal" contact block is the building unit for all types of contactors and relays. Choice of the frame-and-coil assembly and standard assembly kit permits variation in devices to meet your specific application.

Three types of contactors and six types of relays—for general purpose, mill-duty, overload and timing applications—can be assembled using this unique, cost-saving approach.

### NEED OTHER COMPONENTS?

General Electric also has complete lines of plate rheostats and resistors for all your control needs. For more information, contact your General Electric Sales Representative or mail this coupon today! *Industry Control Department, Salem, Virginia.*

# GENERAL ELECTRIC

*Circle 591 on Page 19*

**Resistors**—vitreous-enameled and wire- and ribbon-wound types from 5 to 1210 watts. Fixed, slide-wire, or tapped types available.

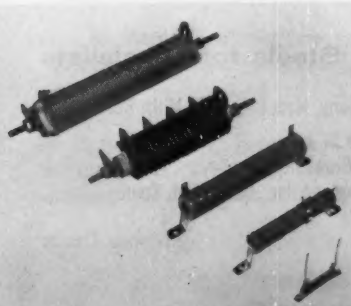
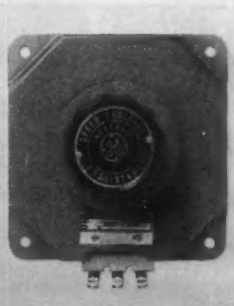


**Plate-type rheostats**—windings are completely encased in metal to give longer and more reliable service for any application.



**To: Section A784-26**
**General Electric Co.**
**Schenectady 5, N. Y.**

Please send the following bulletins:

- ☐ **GEA-6621—D-c contactors and relays**
- ☐ **GEA-6592—Resistors**
- ☐ **GEA-6474—Plate-type field rheostats**

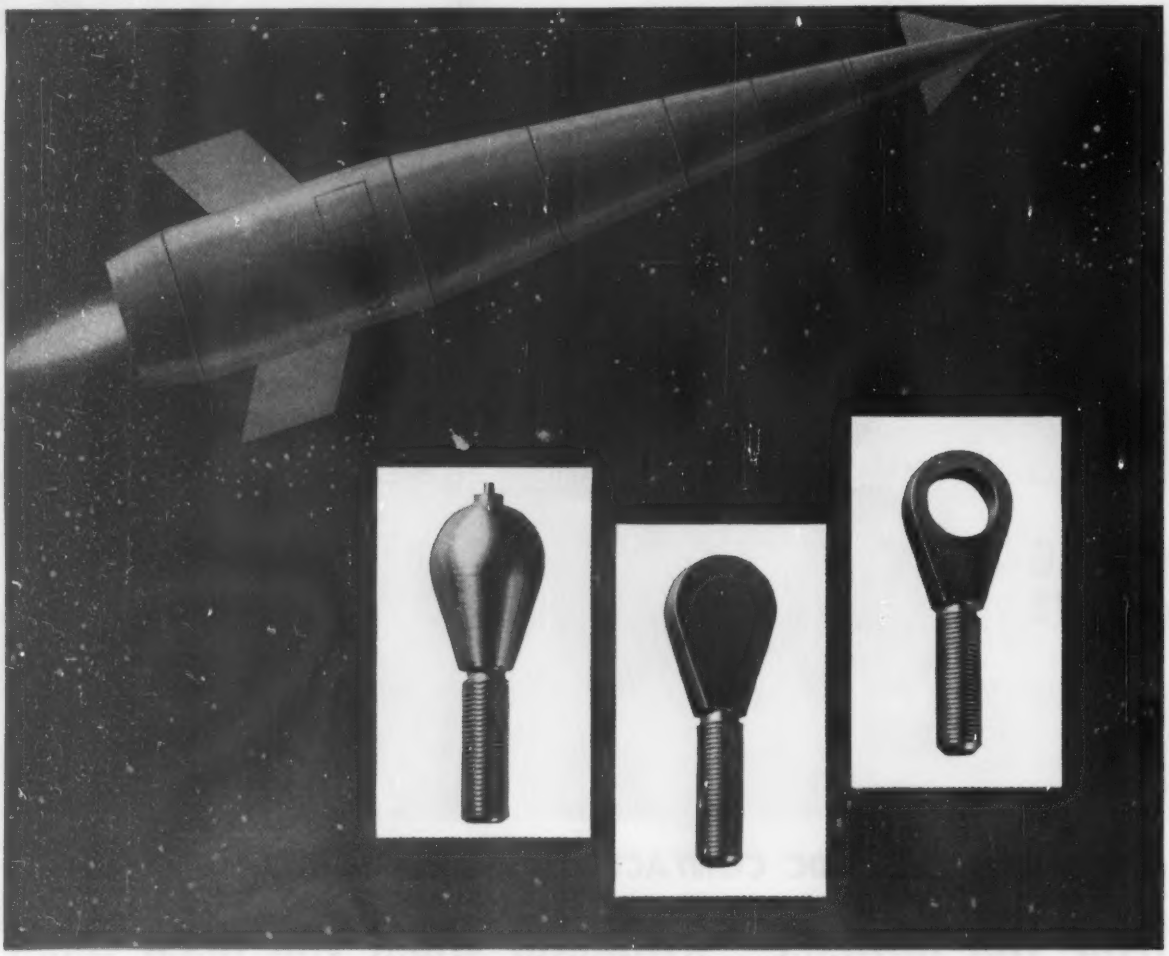
**Name**_____

**Company**_____

**Address**_____

**City**_____

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for strength, corrosion resistance, machinability

and quality finish . . . **it had to be stainless**

*The fabricator made this critical missile part much more reliable by switching from a cadmium plated alloy steel to Carpenter Stainless No. 5 (Type 416). He also eliminated rejects (they had averaged 25%), lowered production costs and increased output nearly 100%.*

*All applications of Carpenter Stainless aren't as spectacular as this, but the results in nearly all cases are proving so beneficial to both fabricator and customer that "Carpenter Stainless" is seen on more blueprints every month. Carpenter has the knowledge and experience to help you make the profitable switch. Contact your nearest representative now. The Carpenter Steel Company, Reading, Pa.*

**Carpenter steel**

you can do it ***consistently*** better with Carpenter Stainless Steels for specialists

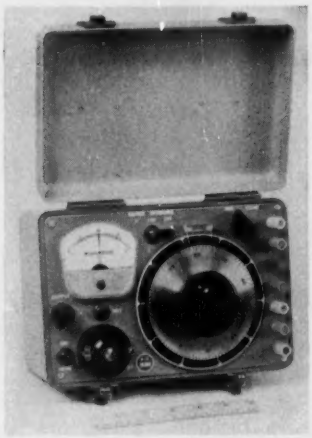
The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

is 20 in. long, 10 in. wide, 9 in. high, and weighs less than 15 lb. It plugs into any standard 100-v ac outlet. **Copymaker Co.**, 3597 Lee Rd., Cleveland 20, Ohio.

*Circle 793 on Page 19*

## *Strain Indicator*

**has total strain range of 60,000 mu in. per in.**



Portable, completely transistorized strain indicator, Model HW-1, requires no phase balance adjustment to maintain sensitivity and accuracy, even when very long leads are used between instrument and strain gages. Total strain range is 60,000 mu in. per in., gage factor range is 1.5 to 4.5. Sensitivity is better than 1 mu in. per in. Instrument can be used with all resistance-type strain gages having nominal resistance from 50 to 2000 ohms. Over-all dimensions are 6 x 9 x 6 in. Weighing only 6 lb, instrument provides ac excitation to the strain gages and uses a null-balance scale for indicating strain. **Strainsert Div., Polyphase Instrument Co.**, East Fourth Street, Bridgeport, Montgomery Co., Pa.

*Circle 794 on Page 19*

## *Drafting Template*

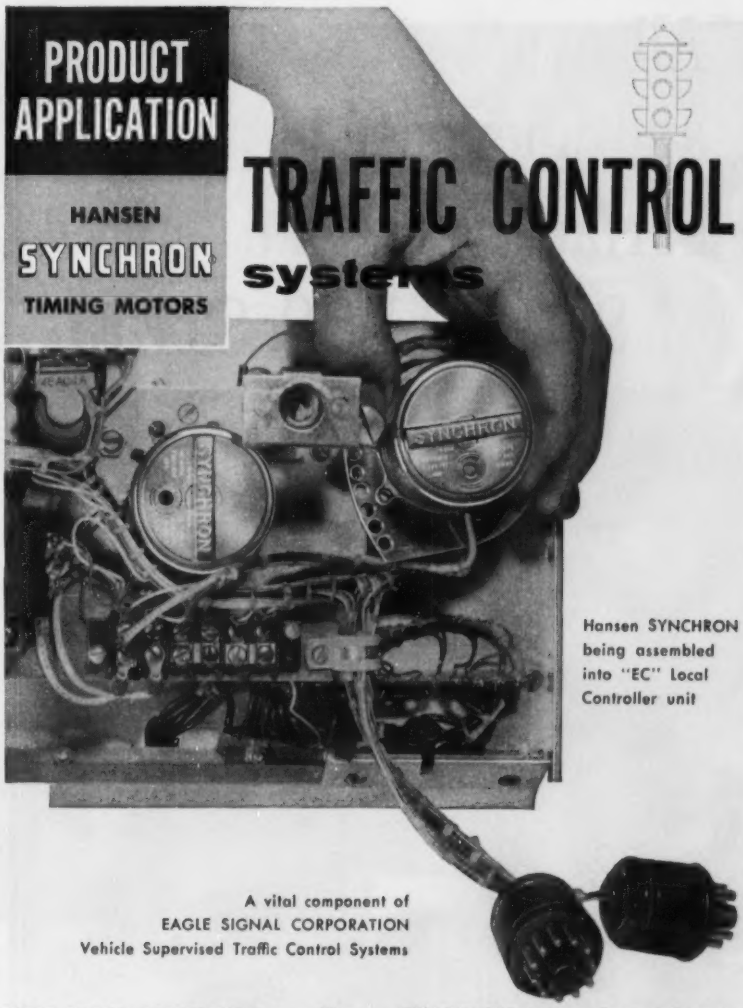
**for hexagon screw heads and nuts**

No. 82 Rapid-Hex template speeds the drawing of hexagon screw heads and nuts in top and side views. Template has a range of $\frac{1}{8}$ to $\frac{3}{4}$ in. of hexagon screw heads and nuts as measured across the flats, and contains 12 hexagons, circles, and


PRODUCT APPLICATION

HANSEN SYNCHRON TIMING MOTORS

TRAFFIC CONTROL systems




Hansen SYNCHRON being assembled into "EC" Local Controller unit

A vital component of
EAGLE SIGNAL CORPORATION
Vehicle Supervised Traffic Control Systems

**EAGLE SIGNAL CORPORATION** uses Hansen SYNCHRON motors for synchronous power to govern signal timing operations in "EC" Traffic Control Systems. Hansen SYNCHRON motors regulate amber and pedestrian clearing intervals — and all other intervals which remain *constant* regardless of cycle length . . . and also govern the 4 independent traffic splits (time division for vehicular traffic) — as well as any interval which is *variable* according to cycle length. The Hansen SYNCHRON, regulating constant intervals, operates on 60-cycle power supply . . . the one governing variable intervals responds to variable frequency from the master control unit.

**HANSEN SYNCHRON TIMING MOTORS** were chosen by Eagle Signal after careful testing of several makes of synchronous motors. Due to the size of some timing devices and control units, a small motor with good performance characteristics was needed to fit the space limitations. After extensive tests, Hansen SYNCHRON motors were specified for: (1) high-quality performance under test; (2) lower cost; (3) long-life operation as an integral part of traffic control units. Since adoption, Eagle Signal has never experienced an assembly slowdown or stoppage due to failure on service or delivery of Hansen SYNCHRON Timing Motors.

**SEND TODAY** for informative folder containing specifications and technical data on all Hansen SYNCHRON motors and clock movements.

HANSEN MANUFACTURING COMPANY, INC.
PRINCETON, INDIANA

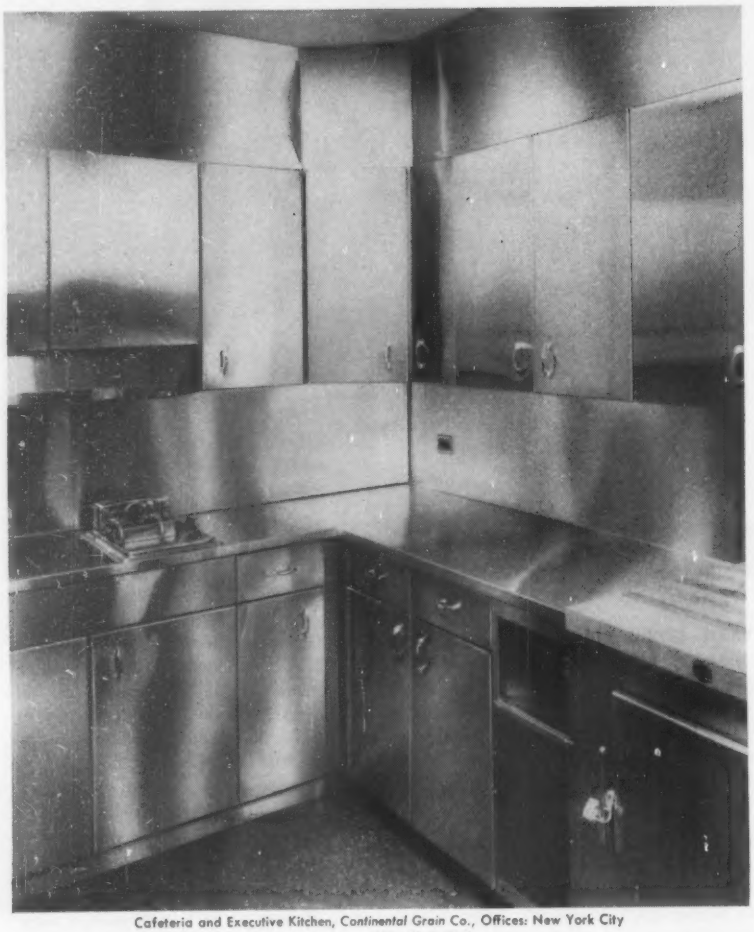
**HANSEN REPRESENTATIVES:**
**THE FROMM COMPANY**
5150 W. Madison, Chicago, Illinois
**H. C. JOHNSON AGENCIES, INC.**
Rochester, N.Y. — Buffalo, N.Y. — Syracuse, N.Y.
Binghamton, N.Y. — Schenectady, N.Y.
**ELECTRIC MOTOR ENGINEERING, INC.**
Los Angeles, Calif. — (WEbster 3-7591)
Oakland, California
**WINSLOW ELECTRIC CO.**
New York, N.Y. — Chester, Conn.
Philadelphia, Penn. — Cleveland, Ohio

**Visit HANSEN Booth No. 711 — ISA Show September 26-30**




*Circle 593 on Page 19*

"All exposed
and unexposed
surfaces shall be
of STAINLESS STEEL..."



Cafeteria and Executive Kitchen, *Continental Grain Co.*, Offices: New York City
Designed by *Designs for Business, Inc.*, New York, N. Y.
Fabricated by *Stainless Food Equipment Co.*, Newark, N. J.
Installed by *Ben Mernit*, New York City

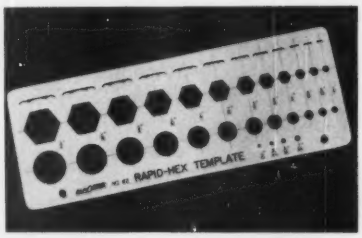
■ The specifications for this executive cafeteria called for all kitchen metal surfaces, both exposed *and* unexposed, to be constructed of stainless steel. Only *lifetime* stainless steel can offer the durability and ease of maintenance necessary for maximum sanitation in food handling.

■ MICROROLD STAINLESS STEEL was chosen for its consistent uniformity of gauge, outstanding finish and well-known fabricating qualities.

■ *Why not investigate the advantages of stainless steel for your next project?*

WASHINGTON STEEL CORPORATION
9-E WOODLAND AVENUE • WASHINGTON, PENNSYLVANIA





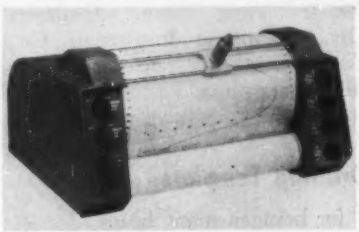

chamfer crescents. It is 0.030-in. matte-finished, mathematical-quality plastic with over-all size of 8 x 2¾ in. Cutouts provide for pencil allowance. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif.

*Circle 795 on Page 19*

## *X-Y Recorder*

**plots directly from computer output**

High-speed, precision plotting of computer-processed data is made possible with a new x-y recorder, Model 560-R. Recorder converts digital information regarding the relative variation of two functions into corresponding incremental motions of the plotting paper and the plotting pen. Graphical representation of the relationship between the two functions is accurate to within 1/100 in., size of the basic plotting increment. Unit accepts data from all digital computers and can be driven by both punched-paper-tape and punched-card data processors. Incremental design eliminates problems of drift, stability, and gain variation. Drum and pen increments are 1/100 in. in either positive or negative direction. High-speed instrument provides up to 200 incremental steps per second on



each axis, and Z-axis modulation can be maintained at up to 10 operations per second. Recorder features roll-paper feed and take-up mechanisms utilizing paper rolls 12 in. wide and 120 ft long. Recorder is completely transistorized and utilizes a self-contained power sup-



*Circle 594 on Page 19*



*A Partlow Model MFS indicating controller is shown in action in this "multiple exposure" shot of a Holo-Core Automatic Molding Machine manufactured by Spo, Inc., Cleveland, Ohio.*

## *The Temperature Control Built to*
## SHRUG OFF SHOCK
## *2438 Times a Day*

Every working day, the Partlow Temperature Control in this photo takes between 2400 and 2500 solid "roundhouse punches" from the shell-molding machine to which it is attached.

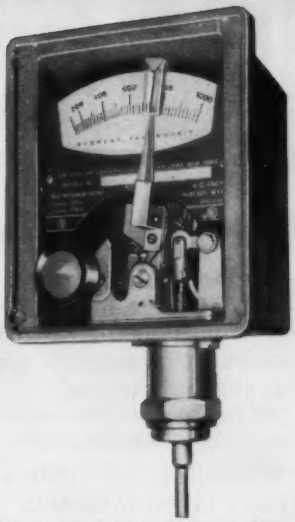
But despite jarring shock and vibration, and a constant barrage of foundry dust, the Partlow goes right on delivering precision control—without letup or breakdown.

Actually, only a control as simple and rock-solid as the Partlow could withstand this kind of punishment! Because only the Partlow contains no hairsprings, or delicate gadgets.

All Partlow thermal elements of the same range are interchangeable *on the job*, too. There's no time lost waiting for your control to come back from the factory. And you get this extra margin of dependability *without loss of accuracy*. Partlow controls are precise to within 1% of scale in any one of 10 ranges from −30° to 1100° F.

If you use or manufacture equipment within this temperature range, there's a Partlow to fit your application exactly . . . and save you money, too. Available in Pneumatic, Electric or Self-Contained Gas types, in recording, indicating or non-indicating models! To field test any Partlow control . . . or to obtain full details write, The Partlow Corporation, New Hartford, N. Y. Dept. D-960.

**Export Ad. Auriema, Inc.,**
**85 Broad St., New York 4, N. Y.**



*A complete absence of gadgets and superfluous parts, as seen in this open view of the new MFS indicating control, explains the Partlow's unique ability to function accurately even under the most severe operating conditions.*

You can pay more but you can't buy better than

**PARTLOW**

**TEMPERATURE CONTROLS**



*One word explains the popularity of these switches...*

# Dependability!

Denison LOXSWITCH Limit Switches operate with the dependability of Old Faithful. Oil- and dust-tight features, superior electrical characteristics and mechanical design result in three to five times longer life than comparable switches.




## L100W HEAVY DUTY LIMIT SWITCH

- 45 CIRCUIT ARRANGEMENTS.
- LONGEST CONTACT LIFE due to lowest impact of 2.5 grams and minimum "bounce".
- WATER-, DUST- AND OIL-TIGHT, NEMA 12.
- ONLY FOUR MOVING PARTS. Longer life, easier to maintain.
- 70° SAFETY OVERTRAVEL without use of extra springs or cams.
- OVER 150 LEVER STYLES.

## MODEL M PRECISION LIMIT SWITCH




- LONG MECHANICAL LIFE nylon latch mechanism.
- 600 VOLT INDUSTRIAL CONTROL RATING.
- COMPLETELY ISOLATED CIRCUITS.
- 8° TRIP DIFFERENTIAL, 50° overtravel in both directions.
- PRECISION REPEATABILITY ± .001".
- WATER-, OIL-, DUST-TIGHT – NEMA 12.
- FULLY INTERCHANGEABLE with thousands of existing layouts.

***BOTH MODELS AVAILABLE WITH PLUG-IN CONVENIENCE***

*Write for literature describing our complete line.*

**Address R. B. DENISON MFG. CO., 386 Broadway, Bedford, Ohio**

# DENISON LOXSWITCH

*Wire with **LOXSWITCH** and you wire for good!*



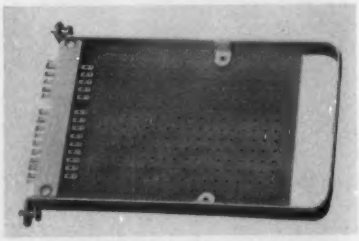

ply. All circuitry is mounted on a removable etched circuit board or in a plug-in power supply module. Recorder is 12 in. high, 18 in. wide, and 14 in. deep. **California Computer Products Inc.**, 8714 Cleta St., Downey, Calif.

*Circle 796 on Page 19*

## *Blank Circuit Boards*

**for experimental and prototype use**

Blank circuit boards with a grid pattern composed of holes for inserting eyelets or terminals are available for assembly of experimental and prototype electronic circuits. Boards permit components to be mounted, connected with jumper wires, and soldered to make a plug-



in electronic circuit. Eyelets or terminals permit practically limitless resoldering. Variety of materials and mounting styles is available. **Plug-In Instruments Inc.**, 1416 Lebanon Rd., Nashville 10, Tenn.

*Circle 797 on Page 19*

## *Drafting Machine*

**has 20-in. arms**

Vemco 3300 drafting machine has 20-in. arms, yet covers a 34 x 44-in. drawing area. Drafter has automatic indexing for positive settings at 15-deg intervals, or free rotation for setting at intermediate angles. Instrument is provided with modern disc brakes to aid in maintaining position on a moderately inclined drawing board. Ball joints within elbow brackets permit easy lifting of the head and scales over objects on the board. Unit accepts any drafting-machine scale which has standard chuck plates. Elbow is reversible, permitting operation to the right or left. **V & E Mfg. Co.**, Dept. NR, 766 S. Fair Oaks Ave., Pasadena, Calif.

*Circle 798 on Page 19*

# "Service Life Increased 600% with URETHANE ELASTOMER parts"

*says James R. Hodde, Sales Engineer*
*Crutcher-Rolfs-Cummings, Inc.*

MULTRATHANE® CASE HISTORY NO. E-6.

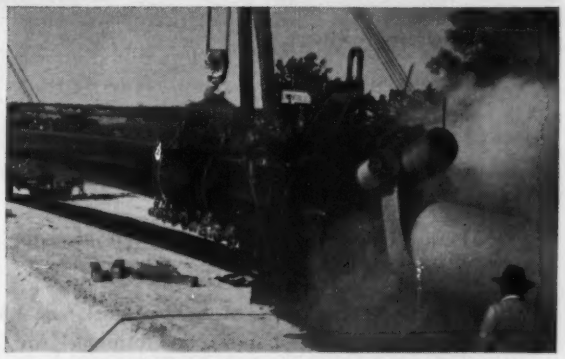


"One of the most brutal tests for any material are the crawler wheels of equipment for cleaning, priming, coating and wrapping pipelines ranging from 2″ to 36″ in diameter," says Mr. Hodde. "Weights of our line travel equipment range up to 9,050 pounds for a 36″ capacity unit. The crawler wheel inserts, leveled at a 27″ angle, and mounted in pairs, must support the entire weight of the machine plus operator, fuel and materials as it travels along the pipeline doing its job.

"Fiber inserts formerly used lasted for only 10 or 12 miles of travel before they were worn so concave their steel flanges began scoring the pipe. Changing the inserts takes 3 to 4 hours with two skilled mechanics. In this time, 40% of the day's production could be lost.

"So dramatic has been the performance of urethane elastomer crawler wheel inserts that they have been standardized on all new equipment at our company, supplied to our specifications by the Acushnet Process Company, New Bedford, Mass. and Fort Worth, Texas."

**This direct case history report from this heavy equipment manufacturer is typical of many others, testifying to the impressive savings in both maintenance and operation costs resulting from urethane elastomer's resistance to wear, abrasion and impact. Write Mobay for complete data on urethane elastomers made with Multrathane® chemicals, showing how you can put this "work-horse" material to work for you.**



Two or more crawler wheels ride on top of the pipe as well as underneath, held in contact by spring loaded arms to insure adequate traction and prevent slippage.

**MOBAY CHEMICAL COMPANY**
**Dept. H-5 Pittsburgh 5, Pennsylvania**

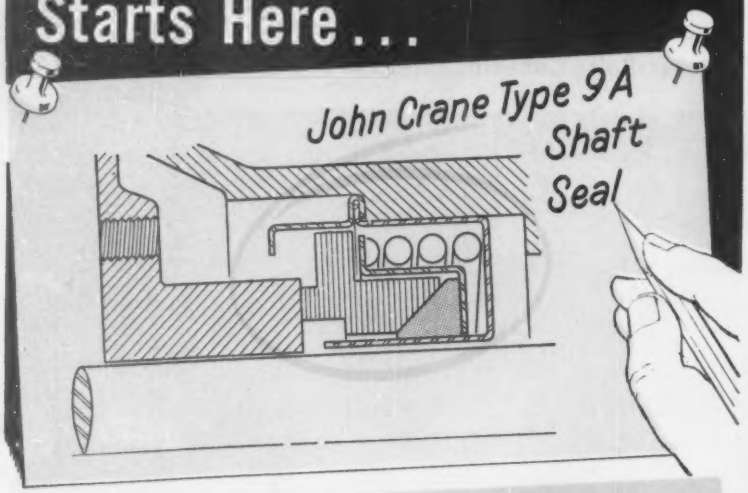
Mobay supplies Multrathane quality chemicals and technology for manufacturing urethane elastomers.

MOBAY
*First in Urethane Chemistry*



*Circle 597 on Page 19*

# Sealing Corrosive Liquids Starts Here...

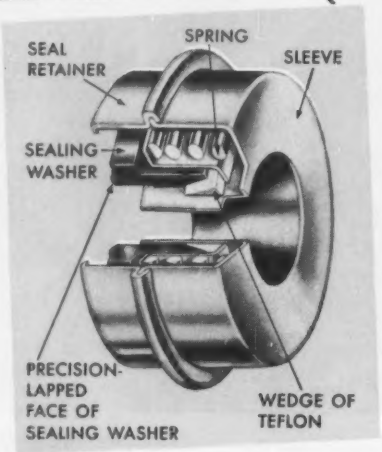



This cartridge-type shaft seal designed for the production line is engineered for:

**(1)** positive sealing of many industrial chemicals and solvents (note the Teflon* sealing wedge);

**(2)** leakproof handling of inflammables and toxics;

**(3)** operation over a wide temperature range from −120° to +500°F., pressures to 150 psi.




It offers the Original Equipment Manufacturers these important advantages:

**(1)** low unit cost through mass production;

**(2)** fast, one-piece installation through cartridge construction;

**(3)** equal efficiency on both low or high speed applications, because seal does not rotate with shaft.

The 9A Shaft Seal can be of stainless steel, monel, brass or other materials adapted to stamping and forming—depending on the service requirement.



Get full details. Request Bulletin S-205-3 from Crane Packing Co., 6425 Oakton Street, Morton Grove, Illinois *(Chicago Suburb)*.
*In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

**DuPont Trademark*




**CRANE PACKING COMPANY**
OFFICES IN ALL PRINCIPAL CITIES


# Professional Viewpoints

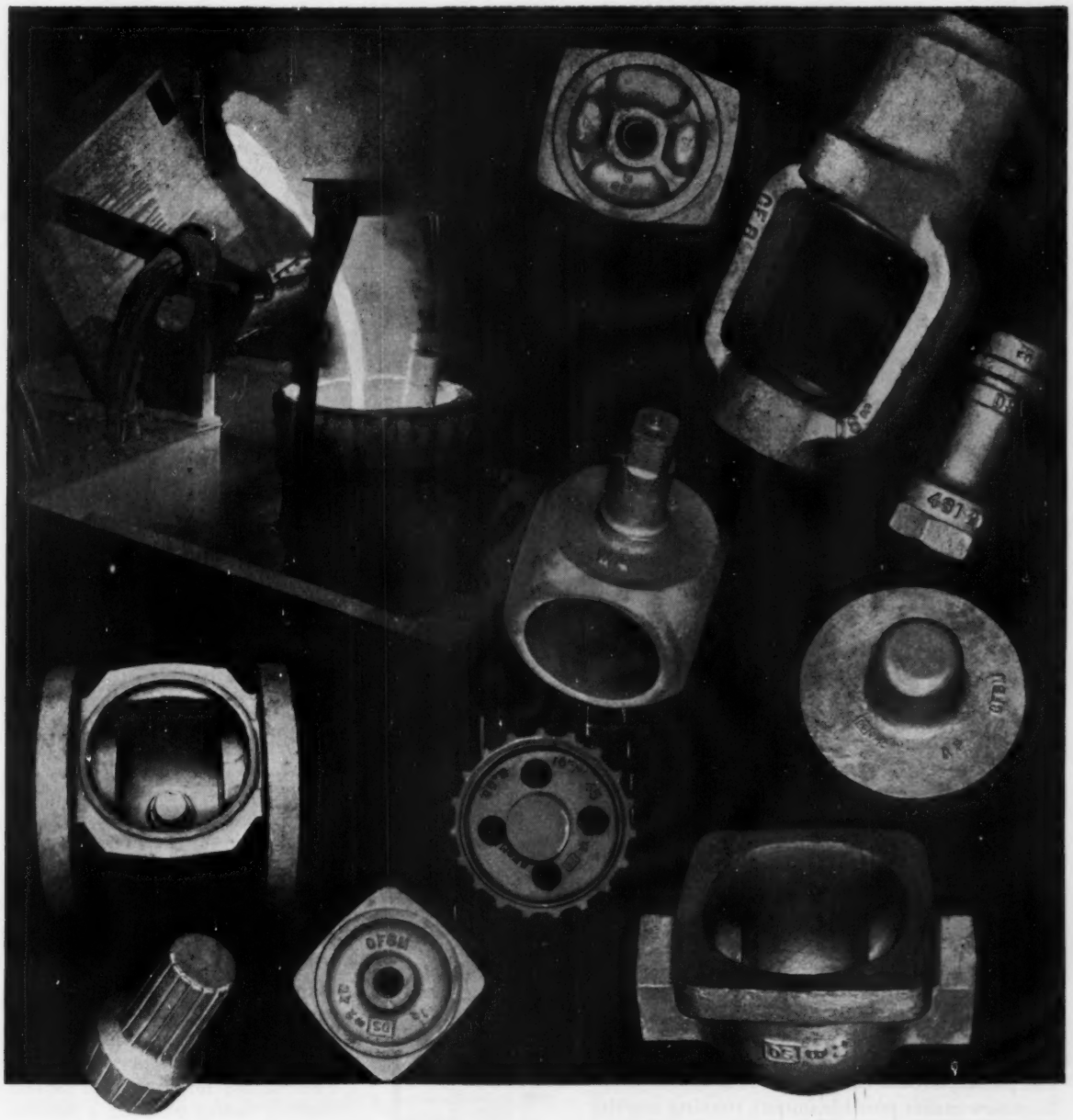
## . . . planetary gear ratios . . .

*To the Editor:*

The article, "Table of Gear Combinations for Planetary Gear Ratios," by H. Reed Langdon (MACHINE DESIGN, April 28, 1960) was very interesting to several of my colleagues and me. Especially, the listing provided is very helpful to avoid the usual fuss when looking for possible tooth combinations. However, with a few tricks we can find more workable combinations. Going to the extreme, using also "parentheses" cases and disregarding extreme streamlining of the design, there is even no restriction at all.

A first possibility for more combinations is seen by using the author's method resulting in his Equation 3. Enlarged size, increased addendum can be applied for higher numbers of teeth also. It is even recommendable for balancing the bending stresses. As an example among many, I mention one case applied for years in mass production: Sun gear, 32, planet 35, ring gear 103.

Secondly, we can go away from equal chordal spacing. The case of sun gear 26, planet 17, ring gear 60, is used as an example. The list provides for only two planets. The second planet is placed at one-half revolution (180 deg) spacing. Now, we can insert a third planet without interference at 21/86, which is about ¼ (90 deg) and a fourth planet opposite the third at 64/86. The arrangement is perfectly balanced. A balanced design is achieved for six planets also, with the planets at the following stations: 0, 14/86, 38/86, 43/86, 57/86, and 71/86. Also, odd numbers of planets (five) should not be neglected among the possible arrangements. However, a dead weight for balancing has to be provided. With this, a perfect external balance is guaranteed. Internal balance, however, meaning equal



# NAME YOUR STAINLESS SHAPE!

The design and manufacture of quality stainless steel castings is a specialized job . . . *and Dodge specializes in it!*

There is practically no limit to the variety of shapes we can turn out to meet your simple or intricate specifications precisely . . . economically.

Perhaps one or more DS castings shown here will help spark an idea of how Dodge can be of assistance for *your* stainless steel casting needs. A blueprint or sketch with operational details will bring complete information, without obligation.

**DODGE STEEL COMPANY**

**6501 State Road**

**Philadelphia 35, Pa.**

• *Phone: DEvonshire 2-2200*

DS DODGE PRODUCTS

THE MOST IMPORTANT ALLOY IN A STAINLESS STEEL CASTING IS QUALITY



*Angular drives clustered in minimum space on stretch reducing mill operate at 8° 10 min. plus or minus.*

# ANGULAR DRIVE DESIGN

## *Now Made Easy with*

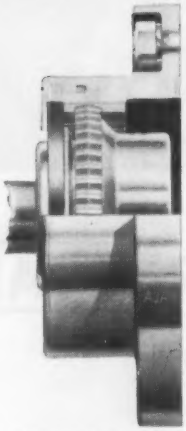
## AJAX Dihedral Couplings

When your design requires angular drives, the ability of Ajax Dihedral Couplings to permit angular and offset shaft alignment may offer a welcome answer.

The patented tooth design of Ajax Dihedral Couplings now makes possible smooth running angular drives in minimum space.

Double engagement and floating shaft types provide a wide range of adaptability to design requirements. Performance has been proved and approved in thousands of installations involving high torque, adjustability, weaving structures and other difficult conditions.

Feel free to draw on the broad experience of Ajax engineers and sales representatives to aid in working out your problems. Refer to the Yellow Pages under "Couplings" or phone or write...



Cut-away view shows typical arrangement of Ajax Dihedral gears specially designed for handling angular and offset shafts.

**AJAX FLEXIBLE COUPLING CO. INC.**

**102 Portage Road, Westfield, N. Y.**

***In Canada—The Alexander Fleck, Ltd., Ottawa***



loads on all gears, is not held in this case. The remaining differences are small, although larger than the usual deviations from ideal spacing created by machining tolerances.

—F. K. Bielitz
*Chief, Mechanics and Dynamics Dept.*
*Lycoming Div.*
*Avco Corp.*
*Stratford, Conn.*

### . . . recruiting engineers abroad . . .

*To the Editor:*

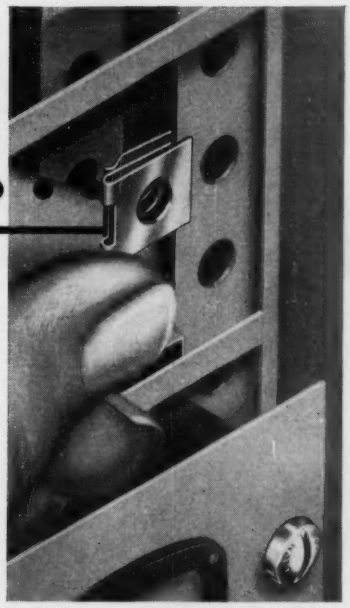
Many companies have successfully implemented their technical staffs in research and development with outstanding foreign specialists in certain fields. Present recruiting techniques can be used for such a program but certain special conditions should be kept in mind. The following discussion of these things is based on successful programs carried out a short time ago in England and on the Continent by engineers of several large corporations. For any program that may be under consideration, it is assumed that the usual interviewing techniques would be employed.

***General Considerations:***

Before a foreign recruiting program is begun, several areas warrant primary consideration: Costs involved, length of time elapsing before the engineers report here [the U. S.] for work, and certain limiting factors affecting a successful endeavor.

**Costs:** Assuming that one individual conducts the program abroad, his initial expenses for a one-month period would be about $1000. This would include the cost of meals and lodging, nominal transportation between foreign countries, and advertising costs. However, it would not include travel expenses from the United States or extra entertainment costs that may be required. First-class air travel for a round trip to the Continent costs about $750, ocean travel, about $550. Other costs (benefits to the applicant) are those which are dependent entirely

# NEW...



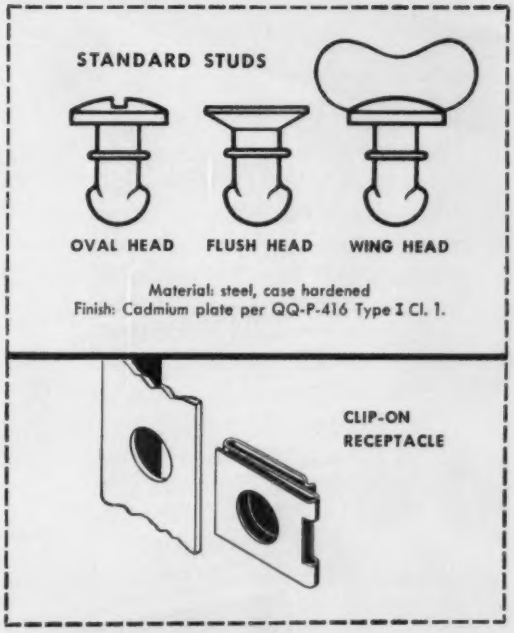
# clip-on receptacle cuts ¼ turn fastener installation time by 86%

## *for* LION ¼ *turn* FASTENERS

Riveting and welding are eliminated by the new, time-saving clip-on receptacle that just slips over a hole in your door frame and locks itself in place.

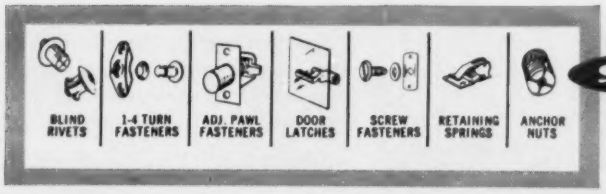
The Lion stud is as easily installed. Slipped through a hole in the panel or door, it is captivated by a split ring retainer. Both the stud and receptacle have a generous "float" to tolerate misalignment of parts.

Operation is fast—¼ turn to lock, ¼ turn to unlock.

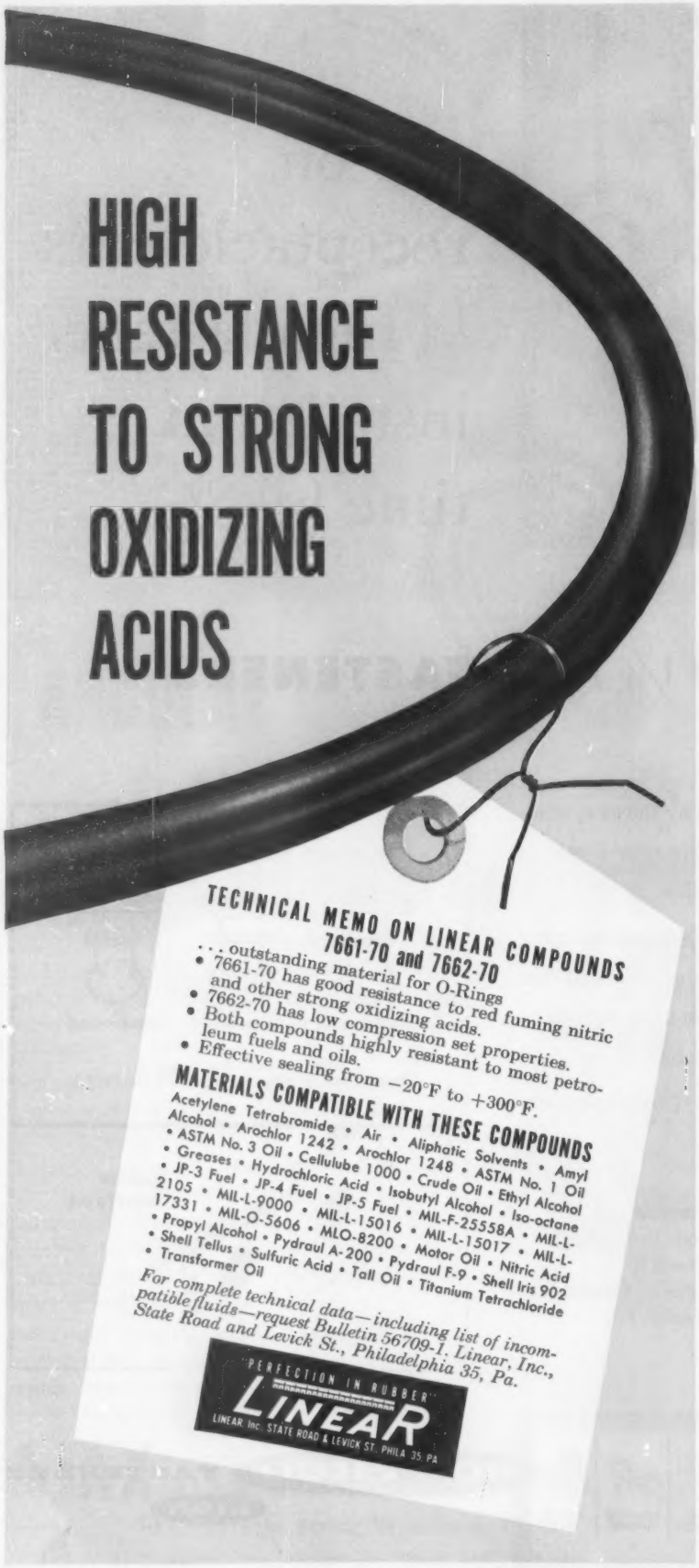



FREE! For complete information on this and other fasteners, send for your free copy of Southco Fastener Handbook, Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

© 1960




SOUTHCO FASTENERS
LION






on company policy for new employees and are discussed later.

**Time Interval:** Depending upon current immigration quotas of the particular country, a period of one to three months may be expected to elapse from the time of application for a visa and the date the engineer reports for work.

**Limiting Factors:** Companies may not wish to start a recruitment program of this type without knowing some of the roadblocks that might be expected. Among those that may place some restriction on the scope of a program are the following:

1. Many countries require that all males complete their military service requirements prior to emigrating.

2. In countries having very small U. S. immigration quotas, natives may have their names on the waiting list for two or three years. However, there are ways of circumventing this problem by applying for emigration to Mexico or Canada initially.

3. If recruiting large numbers of their talented engineers by U. S. companies becomes apparent to politicians of certain parties of foreign countries, this technique might conceivably stimulate controversial political issues.

4. If a U. S. company considers employing engineers from abroad on defense contracts, experience indicates that from 3 to 20 months are often required for the necessary security checks. Obviously the time involved is dependent upon the individual case and the nationality of the engineer. Frequently, the individuals are employed by the company and assigned unclassified or research type projects during the waiting period.

### *Guides for the Program*

Unknown practices in a strange country can often contribute materially to the failure of programs to recruit engineers. Accordingly, a few pertinent comments in this respect are appropriate and should be beneficial to those planning their first foreign recruiting program.

**Advertising:** Because of differ-



Circle 602 on Page 19

Circle 603 on Page 19→



# ON THE HIGH COST OF VIBRATION IN AIR MOVING EQUIPMENT



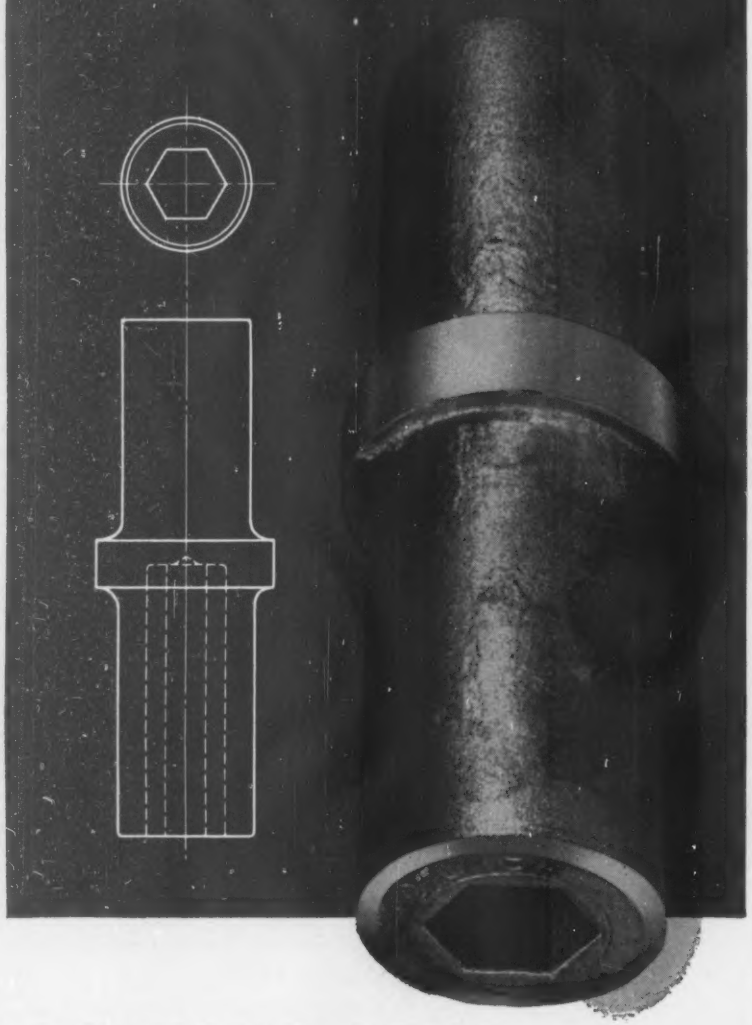
Have you considered the fact that normal excitation in your product can produce resonance and structural failure in the air moving components? We have, and this fact is "pocketbook and problem insurance" for our customers. For instance: We know that motor rotational frequencies... blade frequencies... magnetic frequencies... are basic sources of excitation present in every fan or blower application. When the above coincides with the natural response of the unit, this means resonance and—plenty of trouble. At Torrington, each product of ours is designed, engineered and tested for an optimum range of performance, with harmful or costly resonances "designed out." It pays to know these performance characteristics—and to take advantage of this kind of knowledge. Check your air moving problems or your products with Torrington.

**THE TORRINGTON MANUFACTURING COMPANY**

AIR MOVING DIVISIONS Torrington, Connecticut; Van Nuys, California; Rochester, Indiana; Oakville, Ontario

# PROBLEM:

High breakage in rock drill chucks machined from steel bars.



# SOLUTION:

AmForge developed a forged chuck with a pierced, hexagon hole. Tolerances in the hole were close enough to eliminate machining yet allow friction fit of the drill bits. $1.80 machining cost per chuck was saved. The need for a new machine tool was eliminated. This forged chuck reduced breakage, saved down time, cut production costs.

If you have a similar problem part, consult AmForge. Write for our new brochure or the name of your AmForge Sales Engineer.

Remember: *your problems...our challenge!*

AM FORGE DIVISION

*a division of American Brake Shoe Company, 1220 West 119th Street, Chicago 43, Illinois. Two plants in Chicago, one in Azusa, California.*

WHEN IT'S A VITAL PART, DESIGN IT TO BE FORGED




ences in national currency, rates of monetary exchange, and laws and customs of various countries, our advertising agencies may be limited in performing their usual service for you. In general, it is advantageous to place advertisements for engineers directly with European publishers. Customarily cash payment in advance is required to avoid possible later embarrassment to the publisher. The advertising format and techniques used abroad compare quite favorably with the best in this country.

It is best to print advertisements in English. This automatically eliminates those engineers who cannot read English, which is always required on the job. Requests in the advertisement for written replies often provide a similar means for evaluation and should be supplemented by telephone conversations and/or actual interviews. All of these are means of determining the ability of the applicant to understand and communicate in English and provide a basis for evaluating his technical background and training.

If your hotel location and/or telephone number is given in advertisements, be sure to alert the hotel management. Since advertising for engineers in European newspapers is unusual and generally an exception rather than the rule, hotel managements may be reluctant to have their telephone lines tied up and lobbies overflowing with engineers desiring positions in the U. S. Obviously, judgment and personal tact must be used in contacts with business people and applicants abroad in order to make a recruitment program successful.

**Technical Competence:** In this country, known publications list accredited universities, but such information is practically nonexistent abroad. Organizations such as the Institution of Mechanical Engineers and other professional societies in England and other countries are reliable sources of names of accredited universities. Technical schools abroad, the names of which might be confused with universities, do an excellent job in educating the tech-

# The new LICON® line . . . precision switches for every need

In the new, broadened Licon line you'll find every switch designed to meet modern high capacity, long life requirements. These are switches built to do today's tough jobs. Typical is the unique Type 16—heart of many Licon switch assemblies—tiny in size but rugged enough to handle big switch loads with unbelievable life. Check the unusual "specs" of the Type 16, and all Licon types, against your switch needs—see and compare Licon life against any switch—we're sure you'll specify Licon.



*Send for catalog on new broad* **Licon** *line*

—Gives handy dimensional data and engineering specifications you'll want to keep for ready reference.

**Type 30 Enclosed Limit Switches**—Interchangeable components form up to 16 switch types for quick replacement. High quality, compact, low-priced. 15A., 125V a-c—for industrial applications.

**H—Hermetically sealed Switches**—Designed for dependability in extreme environments. Unique, true hermetic sealing against dust, moisture and other elements. Designed especially to your application.

**Type 14 Heavy-duty Switch**—Built for heavy industrial and machine tool service. Rugged snap-action has large contacts rated 20 amps at 250V a-c.

**Type 10 Long-life Basic Switch**—New Serpentine action mechanism delivers 10 million operations without failure. Can be provided with movement differentials as low as .0005". Rated 15 amps.

**Type 22 Double-pole, Double-throw Switches**—Provide positive control of four independent circuits. Simplifies controls for multiple circuit applications—withstands 25G at 2000 cps. Rated 15 amps., 125/250 V a-c, 30V d-c (res.).

**P—Panel mounted Switches**—Variety of types—to 8 or more poles—some solenoid reset or magnetically held—sealed and unsealed as required.

**Type 11 Snap-action Switches**—Resist 50G vibration to 2000 cps. Double-break, snap-action design eliminates dead break, contact welding and provides greater capacity. Rated 10 amps., 125/250V a-c, 30V d-c.

**Type 16 Subminiature Switches**—Here's big-switch performance in a tiny unit. Only ¼" thick, 25/32" long—yet rated 10 amps, 30V d-c ind. Greatest shock- and vibration-resistance of any switch in its class on the market . . . even near trip point.





# LICON

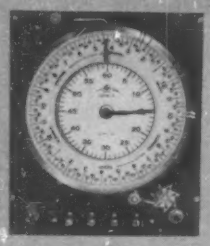
*Available through your local Licon distributor.*

DIVISION OF ILLINOIS TOOL WORKS

6606 W. Dakin Street, Chicago 34, Illinois

Circle 605 on Page 19

# ZENITH TIMERS



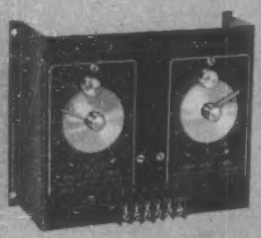
Program Clocks

Interval Timers

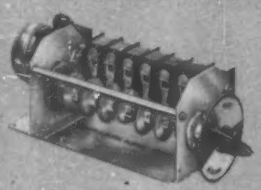




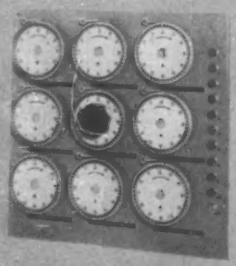
Time Delay Timers



Automatic Reset Timers



Multi-Circuit Cycle Timers



Master Programmers

## FAST DELIVERY... on a Wide Range of Special and Standard Timing Controls

Now, choose the right timer for any control requirement from Zenith's versatile line. Save time and avoid delay. Get prompt engineering and delivery on specials . . . immediate delivery on standard controls.

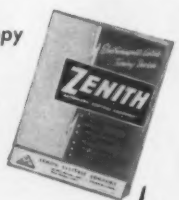
DEPENDABLE—Take advantage of Zenith's experience in engineering and manufacturing quality controls and timing devices for over 35 years.

- Program Clocks
- Time Switches
- Interval Timers
- Time Delay Timers
- Automatic Reset Timers
- Multi-Circuit Cycle Timers
- Percentage Timers
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*Our catalog 18-B also includes*

- Automatic transfer switches engineered to assure continuity of power
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nician or engineers' assistant. However, this difference should be kept in mind when evaluating educational background of European engineers. Although the outstanding Technical universities of the Continent and England number in the hundreds, Delft University (Holland), Cambridge and Manchester Universities (England), and the Swiss Federal Institute of Technology (Switzerland) are a few of those graduating engineers having desired experience and recruited by U. S. companies in the last few years. The technical competence of engineers from abroad—particularly graduates of universities in England and Europe—is extremely high. Many of the new scientific discoveries and technological developments in the past few years have been attributed to such individuals working in our country.

### *Special Considerations*

The problem of salary offers is always a difficult one, whether dealing with American engineers or those recruited from abroad. The going offer rate should *always* be identical for both, assuming the same education and experience level. If offers are different, you may expect personnel problems in a short period of time. Although your offer will seem to be extremely generous to engineers abroad, it must be remembered that their salaries are generally one-third of those in this country. In addition, it must be pointed out that living costs abroad are in the same order of magnitude.

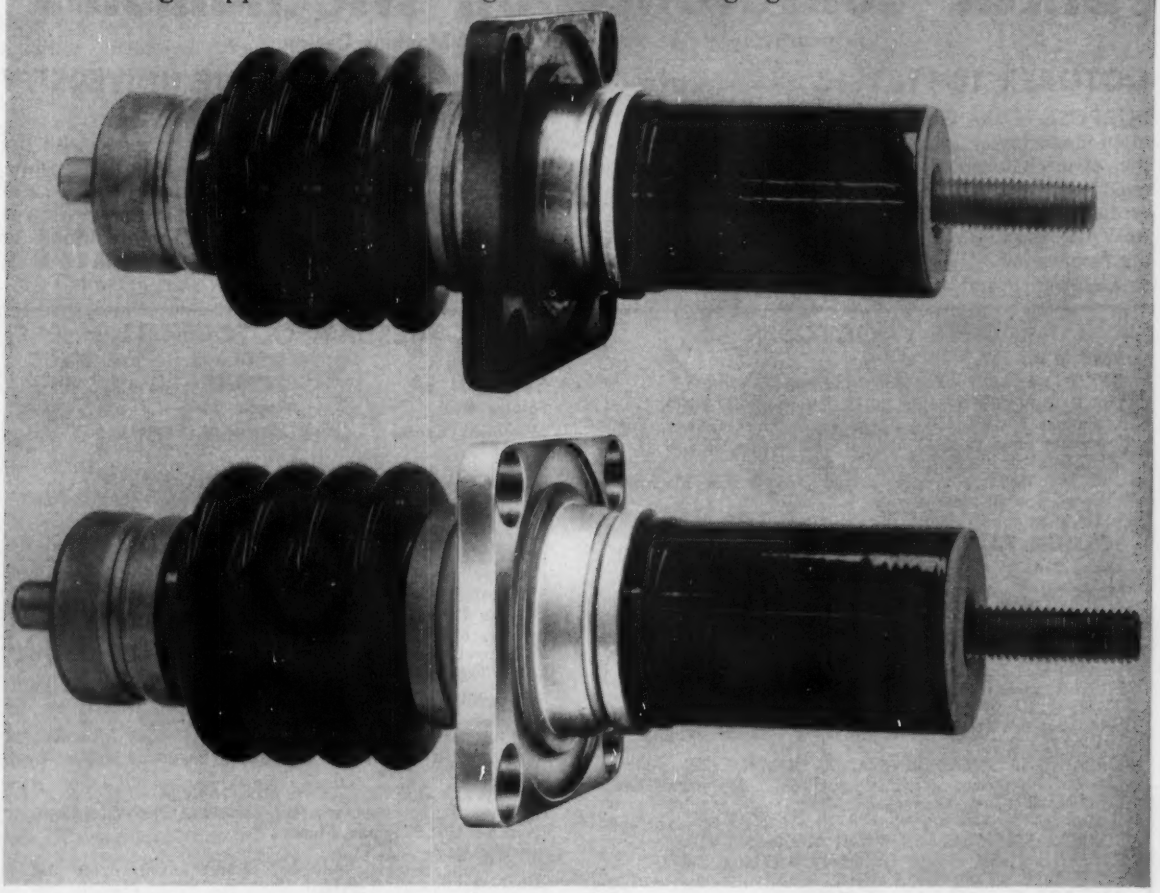
**Contracts:** Some companies have required that employment contracts be signed covering periods of employment up to two years to insure that the individual does not seek other U. S. employment shortly after arrival here. If the companies provide certain financial allowances, this practice might seem to be particularly desirous. Whether contracts are used or not, it is most desirable to confirm any offer of employment in writing together with details outlining any special financial allowances that may be applicable.

Frequently certain special allow-



Circle 606 on Page 19

*New Design Opportunities Through Aluminum Forgings*



# which bushing has 5 new advantages?

The one below—because its flange is a strong, light Kaiser Aluminum forging!

The bushing at the top, used previously on large transformers by Westinghouse Electric Corporation, includes a two-piece steel and copper flange assembly with a brazed joint. The bushing below features the forged aluminum flange that replaced it. Here's why:

1. **Increased Reliability.** With no brazed joint, the possibility of leakage at this point was eliminated, and costly testing of the flange is no longer required.

2. **Simple One-Piece Design.** By designing the bushing flange as one piece instead of two, important cost advantages were realized over the steel and copper assembly.

3. **Added Strength.** The forged aluminum bushing flange is stronger. During the forging process, grain flow lines of the metal concentrate at points of greatest stress to produce a part of maximum strength and toughness.

4. **Light Weight.** The aluminum bushing flange weighs only one-third as much as the steel and copper bushing. Westinghouse saves money on shipping costs.

5. **Corrosion Resistant.** The aluminum bushing flange can't rust, resists corrosion. Costly painting is eliminated.

Find out now how aluminum forgings can best serve your design requirements. We'll be glad to assist you—just mail the coupon!

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KAISER ALUMINUM & CHEMICAL SALES, INC.
Dept. FO-325 (M) Kaiser Center
300 Lakeside Drive, Oakland 12, California

Please send me latest information on commercial aluminum forging availabilities, tolerances and hand forging designs.

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CITY_____ STATE_____

# Sixth Conference on Mechanisms

**cosponsored by Purdue University and Machine Design**

## OCTOBER 10-11, 1960 • Lafayette, Indiana • PURDUE UNIVERSITY

PURPOSE of this continuing series of Conferences is to promote better understanding, design and application of mechanisms. All designers and engineers interested in the design and development of mechanisms are cordially invited.

ADVANCE REGISTRATION may be completed with the form below. The fee of $40.00 includes a banquet on October 10 and a luncheon on October 11, as well as a copy of the *Conference Transactions*.

HOUSING RESERVATIONS may be made with the Union Club on the Purdue campus by the form below. Rooms are also available at the Fowler Hotel in Lafayette (write direct), or those driving may prefer Morris-Bryant Motel, Cedar Crest Motel, Esquire Motel, or Green Acres Motor Court (all 2-4 miles north on U. S. 52).

### MONDAY, OCTOBER 10

**9:30 a.m.**
**SESSION 1—Fowler Hall—Memorial Center**

FOUR CORNERSTONES OF KINEMATIC DESIGN
Thomas P. Goodman, kinematics engineer, General Engineering Lab., General Electric Co., Schenectady, N. Y.

MECHANICS IS NOT A CLOSED BOOK
C. W. Musser, research advisor, United Shoe Machinery Corp., Boston, Mass.

**1:30 p.m.**
**SESSION 2A**
**Room 214**
**Memorial Center**

Session 2A

AN APPLICATION OF POLYDYNE CAM DESIGN
S. A. Okcuoglu, advisory engineer, Engineering Laboratory, International Business Machines, Lexington, Ky.

FILTER THEORY APPLIED TO CAM DYNAMICS
Theodore Weber Jr., consulting engineer, Nyack, N. Y., and chief engineer, Cam Engineering Div., Howard Holmes Inc., White Plains, N. Y.

DESIGNING CAMS FOR ANALOG COMPUTERS
Charles Eumurian, principal engineer, Mechanical Div., General Mills Inc., Minneapolis, Minn.

**1:30 p.m.**
**SESSION 2B**
**Fowler Hall**
**Memorial Center**

Session 2B

SERIES DESIGN OF FOUR-BAR MECHANISMS
Edward E. Hahn, Purdue University, Lafayette, Ind.

LINKAGES WITH ROTATING INPUT AND LARGE OSCILLATING OUTPUT
Raphael Aronson, Purdue University, Lafayette, Ind.

SYNTHESIS OF FOUR-BAR FUNCTION GENERATORS
J. P. Vidosic, professor of mechanical engineering, and H. L. Johnson, research engineer, Georgia Institute of Technology, Atlanta, Ga.

FOUR-BAR STRAIGHT-LINE MECHANISMS
Delbert Tesar, Department of Applied Mechanics, Kansas State University, Manhattan, Kans., and James C. Wolford, Department of Engineering Mechanics, University of Nebraska, Lincoln, Nebr.

**6:30 p.m.**
**BANQUET—Ballroom—Memorial Union Building**

Charles H. Lawshe Jr., dean of university extension services and professor of industrial psychology, Purdue University, Lafayette, Ind.

### TUESDAY, OCTOBER 11

**8:30 a.m.**
**SESSION 3A**
**Fowler Hall**
**Memorial Center**

Session 3A

STATICS AND DYNAMICS IN 3-D MECHANISMS
Rudolf A. Beyer, visiting professor, Mechanical Engineering, Yale University, New Haven, Conn.

SPACE LINKAGE LAYOUTS ON A COMPUTER
D. W. Zawada, systems research department, Ford Motor Co., Dearborn, Mich.

SYNTHESIS OF PLANE MECHANISMS
Douglas P. Adams, associate professor of mechanical engineering, Massachusetts Institute of Technology, Cambridge, Mass., and Alexander Samoiloff, engineer, E. B. Badger Co., Cambridge, Mass.

**8:30 a.m.**
**SESSION 3B**
**Room 214**
**Memorial Center**

Session 3B

THE CARDAN POSITIONS OF A PLANE
Ferdinand Freudenstein, associate professor and chairman, Department of Mechanical Engineering, Columbia University, New York

INVERTED SLIDER-CRANK MECHANISM
George A. Bucci, design engineer, Servo and Mechanics Dept., Raytheon Co., Wayland, Mass.

SIX-BAR LINKAGES
A. C. Dunk, associate professor of mechanical engineering, Purdue University, Lafayette, Ind., and C. L. Hanson, mechanical engineer, Lawrence Radiation Lab., University of California, Livermore, Calif.

**12:15 p.m.**
**LUNCHEON—Faculty Lounge—Memorial Union Building**

ENGINEERING EDUCATION IN THE NETHERLANDS
W. L. H. Schmid, dean of mechanical engineering, Technological University of Eindhoven, Eindhoven, Netherlands

**1:45 p.m.**
**SESSION 4—Fowler Hall—Memorial Center**

PROSTHETIC MECHANISMS FOR LEG AMPUTEES
C. W. Radcliffe, University of California, Berkeley, Calif.

GENERAL DISCUSSION

---

**Mail to: MECHANISMS CONFERENCE, Comptroller's Office (University Extension Administration, Room 110, Memorial Center), Purdue University, Lafayette, Ind.** 232.105

### ROOM RESERVATION

Please reserve in the Union Club the accommodations checked:
Nights: Oct. 10 ☐ Oct. 11 ☐
Single Bed—Bath ☐
If necessary, will share twin-bed room with another Conference member ☐
Twin Beds—Bath ☐
Room will be shared by _____

Please send confirmation:

Name _____
Company _____
Address _____

### CONFERENCE REGISTRATION

The following persons plan to attend the Mechanisms Conference, October 10 and 11, 1960 (name and title, please):

Fee enclosed
_____ ☐
_____ ☐
_____ ☐

$_____ is enclosed for the registrations checked at $40 each. (Make checks payable to Purdue University.)

☐ Fees will be paid at registration time.

Name _____
Company _____
Address _____

ances are offered foreign engineers to assist them in making the transition to the U. S. Depending upon company policy for new technical employees, there may be complete or partial allowances for the following:

1. Reimbursing applicants for interview expenses when invited for interview in countries abroad.
2. Defraying visa costs for the engineer and/or his family.
3. Payment for shipping personal effects and limited amount of household effects to the U. S.
4. Defraying travel expenses to the U. S. for the individual and/or his family.
5. Special allowance (frequently for one week) for subsistence until suitable housing is located upon arrival in this country.

### *Satisfactory Results*

With the knowledge of experiences of others as discussed above, successful low-cost programs can be devised and carried to fruition in a short period of time. Although the costs will vary as the scope of any program, in one case costs to obtain 12 engineers abroad averaged $690 per man. While there may be some limitations in pursuing programs to recruit engineers abroad, many companies have been most satisfied with the results they have obtained.

—R. NORTHRUP
*Strafford, Pa.*




"You've drawn everything upside down again."



CAUSTIC SOLUTION

**A CASE IN POINT**—This is a 19 pound Ni-Resist valve body designed to handle caustic fluids at 400 psi. It was cast for the John Bean Division of Food Machinery & Chemical Corp. Ni-Resist is ideal for this application because it combines high corrosion resistance with superior resistance to erosion from high velocity fluids.

The intricate coring required demands unusual skill to produce Ni-Resist castings leak-proof at 400 psi operating pressures. Hamilton Foundry succeeded in producing pressure tight castings, an accomplishment difficult for the best of foundrymen.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

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Circle 608 on Page 19

NOW! Stainless UNITCASTINGS



**A Complete Range of Heat and Corrosion Resistant Steel Castings . . .**

Unitcast's 40 years experience as one of the nation's most progressive steel founders, now expands its proved engineering and production facilities to serve the "stainless" market.

Typical of such requirements is illustrated by the fluid pump chamber that pressurizes corrosive liquid. Cast to specification CF-8 (A.I.S.I. 308), this casting will provide long, corrosion-free service to improve the product dependability.

Industrial users of Unitcast's advanced methods in stainless steel as typified by manufacturers that produce oil well equipment, special valves, pumps, compressors and turbines, food processing machinery, dies and fixtures, and heat treating equipment.

An analysis of your needs incurs no obligation on your part. Our technical staff may provide the answer to your problem. Get in touch with us today!

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**Unitcast**

**SPECIFICATION STEEL CASTINGS**


# THE ENGINEER'S Library

## Recent Books

**Theory of Thermal Stresses.** *By Bruno A. Boley and Jerome H. Weiner; 586 pages, 6¼ by 9¼ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$15.50 per copy postpaid.*

Thermal stress is explained through the basic subjects of thermodynamics, heat-transfer theory, elasticity, and inelasticity. Theoretical techniques are presented for determining stresses produced in a solid object when it is subjected to specified heating conditions. Some practical methods of temperature and stress analysis are also discussed.

A section on thermoelasticity discusses thermal stresses in beams, plates, rings, trusses, frames, and built-up structures. Viscoelastic and plastic stress analyses are discussed in a section on thermo-inelasticity.

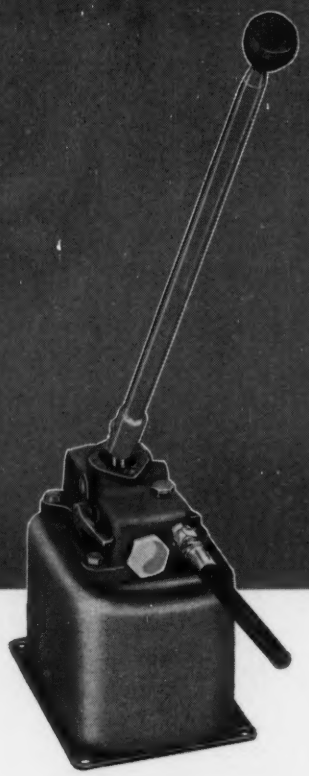
**Elementary Theoretical Fluid Mechanics.** *By Karl Brenkert Jr., associate professor of applied mechanics, Michigan State University; 348 pages, 6¼ by 9¼ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$7.50 per copy postpaid.*

Derivation and application of fundamental equations of fluid mechanics are emphasized. Calculus is employed extensively in general theoretical analysis and in particular problem solving. The control-volume approach is used to derive general equations of continuity, energy, momentum, and angular momentum.

Dimensional analysis and dynamic similitude are included because they provide different approaches to solution of engineering problems.

**Barriers to Creativity.** *Prepared by Deutsch & Shea Inc., technical manpower consultants; 33 pages, 8½ by 11 in., paper-*

# Hand Pumps Still Provide Low Cost "Stand-by" Fluid Power



- Compact Pump-Valve Design
- Multi-Position Mounting
- Quick Pressure Build-Up
- Output Up to 1⅓ cu. in. Per Stroke
- Operating Pressures to 5,000 psi

COMMERCIAL hydraulic hand pumps are expressly engineered for installation on lower cost, utility equipment sold for intermittent or "stand-by" service.

Typical applications are: (a) small highway trucks requiring a pump to operate cylinders that position snowplow blades used only seasonally, (b) fork-lift trucks, (c) tilt bed trailers, and (d) rotary tillers.

COMMERCIAL hand pumps are operated with little manual effort, and because they occupy small envelope space can be mounted in the most convenient operating position.

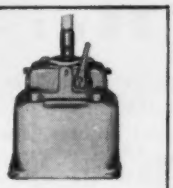
Many quality features insure trouble-free service often beyond the life of the equipment on which they are installed. Features such as: renewable steel check valve seats; pump plunger seats that absorb wear and can be easily replaced; stainless steel, spring-loaded check balls; and full porting to maintain ample oil supply.

All expendable parts are relatively inexpensive, readily obtainable and easily replaced.

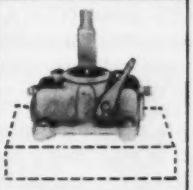
**Hand Pump Performance Data**

| Model Number | Piston Dia. | Delivery Per Stroke (cu. in.) | Required Force (lbs.) on Pump Handle at Various Circuit Pressures (psi) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1000 psi | 1500 psi | 2000 psi | 3000 psi | 4000 psi | 5000 psi |
| B301 | 9/16" | .2485 | 16 | 24 | 32 | 48 | 64 | 80 |
| B304 | 3/4" | .4418 | 28 | 42 | 56 | 84 | — | — |
| B307 | 1-5/16" | .6903 | 44 | 66 | 88 | — | — | — |
| B309 | 1-5/16" | 1.353 | 88 | — | — | — | — | — |

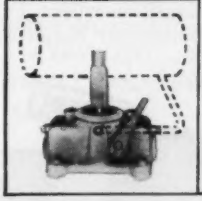
**3 Types of Pumps Tailored to Your Installation Requirements**



**(A)** Complete unit: Hand Pump-Valve, and integral oil tank in either ½ gallon or 1 gallon capacity. Four holes in base for mounting.



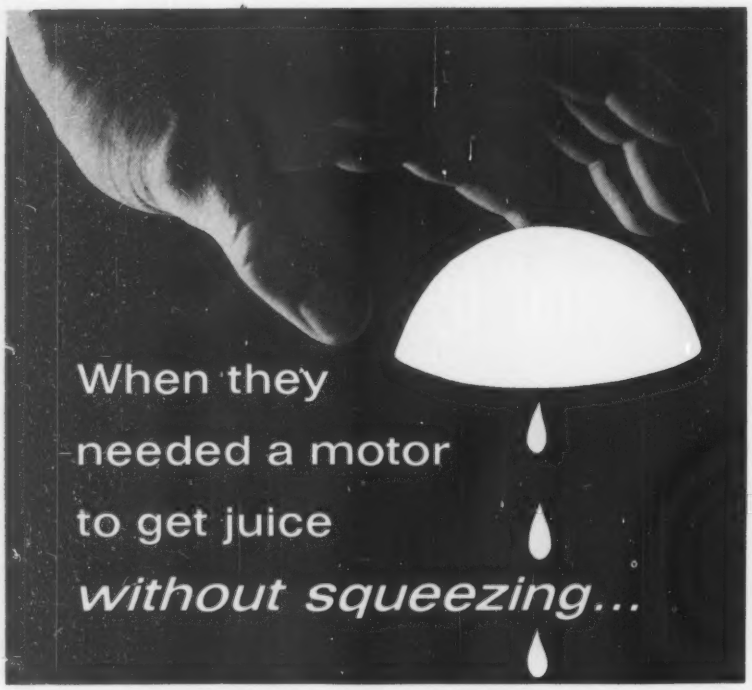
**(B)** Hand Pump-Valve... for top mounting to your tank.



**(C)** Hand Pump-Valve... with ¼ inch pipe tap at side of pump for connecting your low pressure hose and remote supply tank.

If you need a low initial cost, simplified hydraulic system to position components on your original equipment, it might well pay to investigate the COMMERCIAL line of long-life hand pumps and cylinders. Write for free Catalog H-1. Address: Commercial Shearing & Stamping Company, Dept. S-38, Youngstown 1, Ohio.

**COMMERCIAL shearing & stamping**



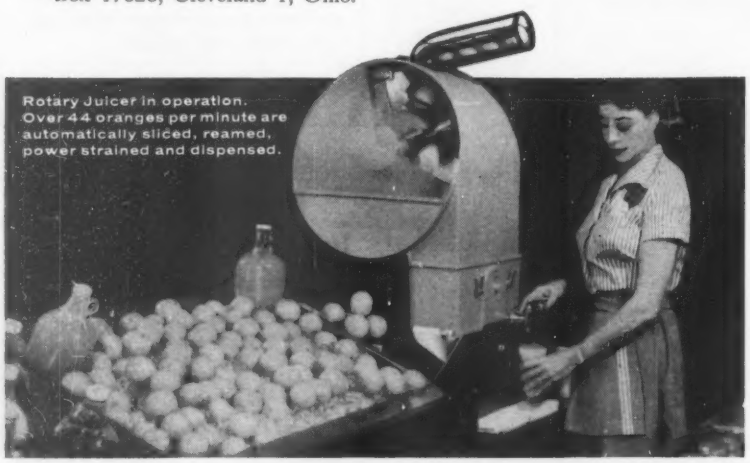

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**JACK & HEINTZ**

Rotary Juicer, Inc., Los Angeles, designed its new restaurant-size orange juicer to ream oranges instead of squeezing them, to avoid normal waste matter usually found in juice. They turned to Jack & Heintz for a customized motor.

The J & H answer was a 56-frame motor with starting torque 20% above, and breakdown torque 45% above NEMA values. Special venting allows low-temperature operation and minimizes heat passed into the juice. So compact and well integrated was the motor design that over-all dimensions of the juicer were reduced 20%.

Like Rotary Juicer, Inc., designers, design *your* product to do the job . . . not to fit a motor. Whatever your motor need, you set the electrical, physical and environmental conditions. We'll do the rest. Range: ⅙ to 3 hp, up to 15 hp for submersibles. For further data, write: Jack & Heintz, Inc., Commercial Motor Division, P. O. Box 17626, Cleveland 1, Ohio.


Rotary Juicer in operation. Over 44 oranges per minute are automatically sliced, reamed, power strained and dispensed.



*bound; published by and available from Industrial Relations News, 230 West 41st St., New York 36, N. Y.; $1.50 per copy.*

Factors that can block creative engineering and scientific activity are outlined, and methods for recognizing and overcoming these factors are presented. Topics include emotional blocks, need for superficial security, using the unconscious, and work-oriented blocks.

Checklists are provided as guidelines for evaluation of reactions in creative situations.

**Spark Machining.** *72 pages, 5½ by 8½ in., paperbound; published by and available from Machinery Publishing Co. Ltd., National House, 21 West St., Brighton 1, England.*

In the last eight years, spark machining has developed to a point where it provides solutions to a number of important engineering problems. These include accurate forming of hard engineering materials such as forging dies, and production of noncircular holes and profiles. This book presents a general review of spark-machining principles, equipment, and applications.

**Broaching.** *By C. Monday; 162 pages, 5½ by 8½ in., paperbound; published by and available from Machinery Publishing Co. Ltd., National House, 21 West St., Brighton 1, England.*

Although this book is primarily for tool and production engineers, design engineers may find it helpful in providing insight into a major production process. The broaching process, design of broaches, applications of broaching, broaching machines, and internal and surface broaching are discussed.

**Elliptic Functions with Complex Arguments.** *By F. M. Henderson, senior lecturer in civil engineering, University of Canterbury, New Zealand; 200 pages, 8 by 11 in., clothbound; published by and available from University of Michigan Press, Ann Arbor, Mich.; $8.00 per copy.*

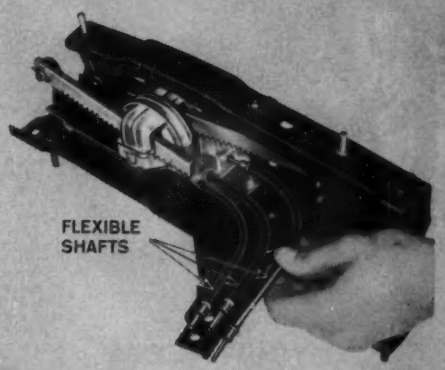
This book contains tables and charts that can be used in the solution of mapping problems of hydrodynamics, heat conduction, and electromagnetics. Particular applications include fluid-flow problems in which two free surfaces map into a rectangle on the hydrograph

S. S. White

DRIVE AND CONTROL IDEAS FOR ENGINEERS



**HEART OF THE POWER-SEAT MECHANISM...** Two slave units, on the left and right sides of seat, are driven by flexible shafts to provide three-way motion. A *single* ¼-hp motor attached to a geared drive unit is the power source. Flexible shafts rotate at 1250 rpm, carry 9 in.-lbs. of torque at running load (three persons) and 15 in.-lbs. at full stall speed.




# Flexible Shafts Solve Space Problems in Chrysler Power-Seat

Chrysler Corporation faced a design challenge in its power-operated seat adjuster. Six-way motion was called for: fore and aft, up and down, and tilt. Yet there was limited space under the seat for the mechanism. After much Chrysler testing and development, a design submitted by subcontractor Ferro Stamping Company was approved, utilizing flexible shafts.

According to Chrysler, the decision to go to flexible shafts was based on the following advantages:

**1. SPACE ECONOMY..."flexible shafts provided means to transmit power from a single electric motor, without compromising seat design."**

**2. REDUCED STRESSES..."flexible shafts act as torsion bars to reduce motor armature stresses induced when the mechanism was stopped or stalled suddenly."**

**3. RELIABILITY..."not a single shaft fatigue failure reported from the field to date."**

**4. LOW COST..."flexible shafts definitely represented savings without sacrificing design advantages."**

Investigate for yourself how flexible shafts can solve many of your design problems and at the same time reduce costs!

**S. S. WHITE INDUSTRIAL DIVISION,** Dept. 4 , 10 East 40th Street, New York 16, N.Y.

1098



**THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK**
**New 4th Edition...Send for your free copy!**

This authoritative handbook has been recently revised to include new selection and application data for S. S. White Standard . . . Pre-engineered . . . Custom-designed flexible shafts.

S. S. White — IN FLEXIBLE SHAFTS




**Never willing to settle for just adequate equipment, standard techniques or regular customer servicing, Alloy Products Corp. sets the pace again for the stainless steel fabricating industry. Increased production capacity and a new "alert!" system of handling assignments makes it possible for A-P-C's stainless steel craftsmen to provide you with components and parts far faster, far better than ever before.**

New purchases of modern, high speed equipment, including a new triple action, deep draw press have doubled plant capacities.

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Best of all, A-P-C's famous quality conscious craftsmen assure you of high precision and detailed attention whether your product is complex in shape or standard in pattern and size.

Look for special service when your next stainless steel process requirement arises. Look to the stainless steel craftsmen of A-P-C when you want:

**Unbelievably Deep Draws**
**Precisioned Automatic Heli-Arc or Manual Weldments**
**Close Tolerance Machining**
**Mirror-like Polishing and Finishing**

*Specializing in stainless steels only . . . all under one roof*

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1067 Perkins Avenue
Waukesha, Wisconsin

Circle 613 on Page 19




plane, and geometric resistance problems introduced by heat conduction.

Charts are drawn up to display the solution of the typical mapping problem, and to show in compact and convenient form, the complex values of the elliptic function for the whole range of complex values of the argument.

## Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

**PB 151077. A Review of Certain Ferrous Castings Applications in Aircraft and Missiles.** By John Varga Jr., Battelle Memorial Institute; 54 pages, 8½ by 11 in., paperbound; $1.50 per copy.

This report describes significant advances in the application of steel castings to aircraft and missiles. Tensile properties of heat-treated steel castings are listed in tables, and a variety of complex aviation castings are illustrated in photos. Requirements are presented for aircraft and missile steel castings, and various casting processes.

**PB 161091. Steady State Response of a Simple System with a Hysteretic Spring.** By Edward R. Rang. University of Minnesota; 16 pages, 8¼ by 10¾ in., paperbound, stapled; $0.75 per copy.

Spring characteristics of a simple spring-mass system are chosen to simulate hysteresis loops found for systems in which damping is due to energy dissipation of materials or fabricated joints. Procedures for approximate calculation of response are outlined.

**PB 161116. Research Program on High Vacuum Friction: Final Report.** By Litton Industries of Calif.; 160 pages, 8 by 10½ in., paperbound, side-stapled; $3.00 per copy.

A two-part study of surface friction was conducted under high-vacuum conditions ($10^{-5}$ to $10^{-6}$ mm Hg). First part describes preparations necessary to conduct experiments. Second part explains the methodical examination of friction characteristics of a large group of metallic and nonmetallic samples. Linear motion between two dry, clean, unlubricated, flat surfaces comprised the principal test condition.

**PB 161264. Handbook of Methods of Cooling Air Force Ground Electronic Equipment.** By James P. Welsh and Thomas J. Walsh; 636 pages, 8 by 10½ in., paperbound, Accopress binder; $8.00 per copy.

This comprehensive thermal-design handbook discusses various modes of heat transfer, and presents theory, data, and computational methods for achieving successful thermal designs. Separate chapters are devoted to thermal design, natural cooling methods, forced-air cooling, liquid cooling, thermal criteria, and thermal limitations of parts.

**PB 161405. A Study of the Relationship between Notched and Unnotched Specimens of 2024 Aluminum Alloy in the Low-Cycle Fatigue Regime.** By Richard D'Amato and Robert De Boer, Massachusetts Institute of Technology; 70 pages, 8¼ by 10¾ in., paperbound, stapled; $2.00 per copy.

An experimental fatigue investigation was conducted in the life range between 1 and 10,000 cycles to failure with notched and unnotched specimens of 2024 aluminum alloy. Notched specimens with theoretical, elastic stress-concentration factors of 2.0 and 4.0 were cycled between limits of deformation across the notch. Unnotched specimens were cycled between limits of elongation measured over a ⅝ in. gage length. Results are tabulated and graphed, and discussed.

**PB 161425. Damping of Flexural Vibrations by Alternate Visco-Elastic and Elastic Layers.** By Eric E. Ungar, Donald Ross, and Edward M. Kerwin Jr., all from Bolt Beranek and Newman Inc.; 38 pages, 8¼ by 10¾ in., paperbound, stapled; $1.25 per copy.

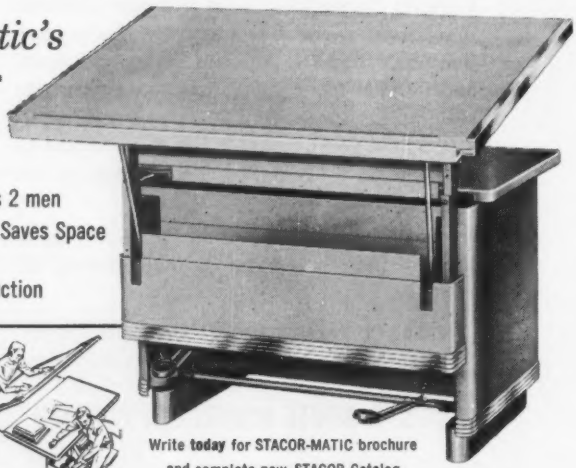
Damping tapes with viscoelastic and stiff constraining layers were tested for their ability to absorb flexural vibrations. Effects of using nonequal tapes were compared with double-tape applications. Experimental and theoretically predicted results were in good agreement.


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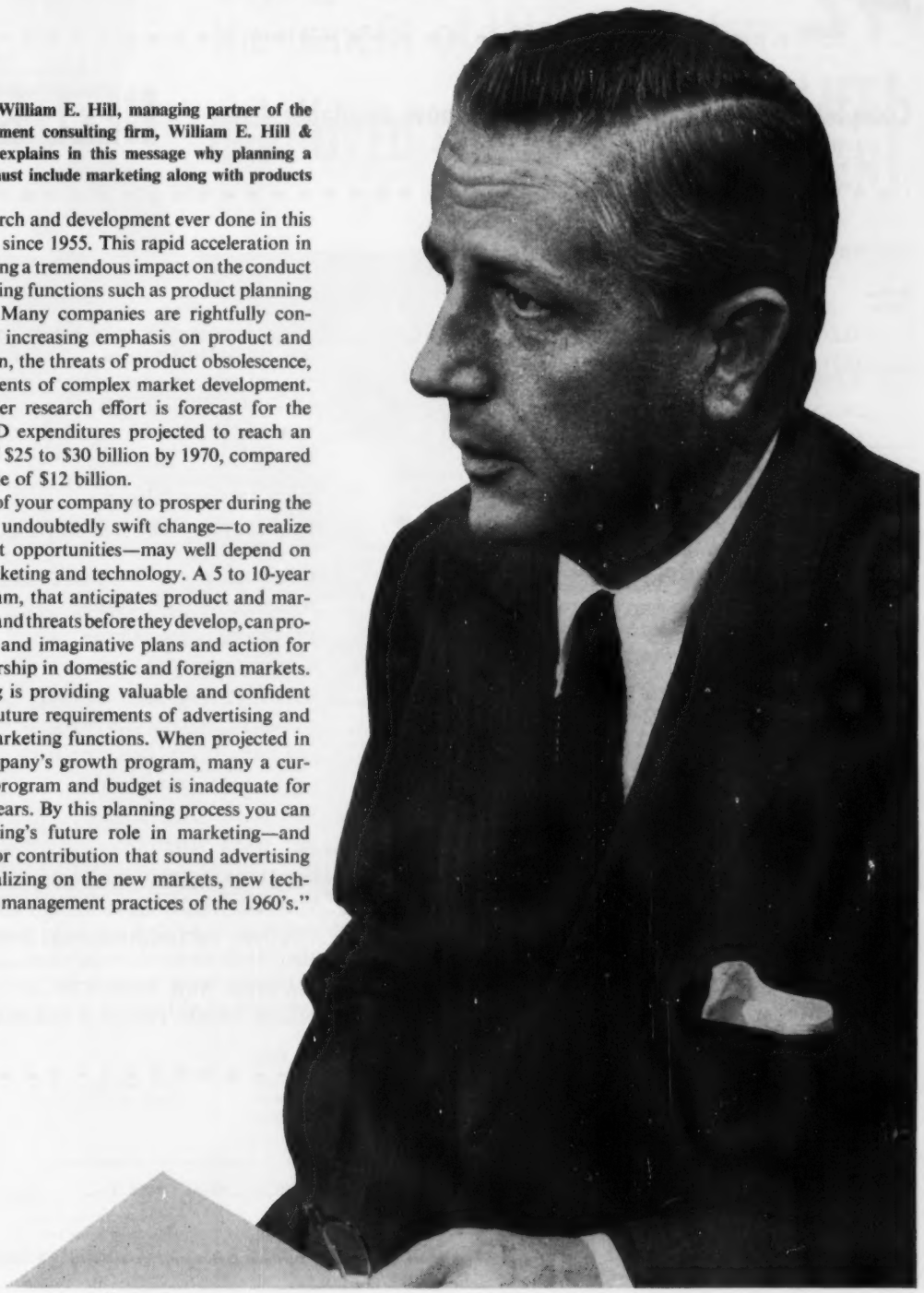
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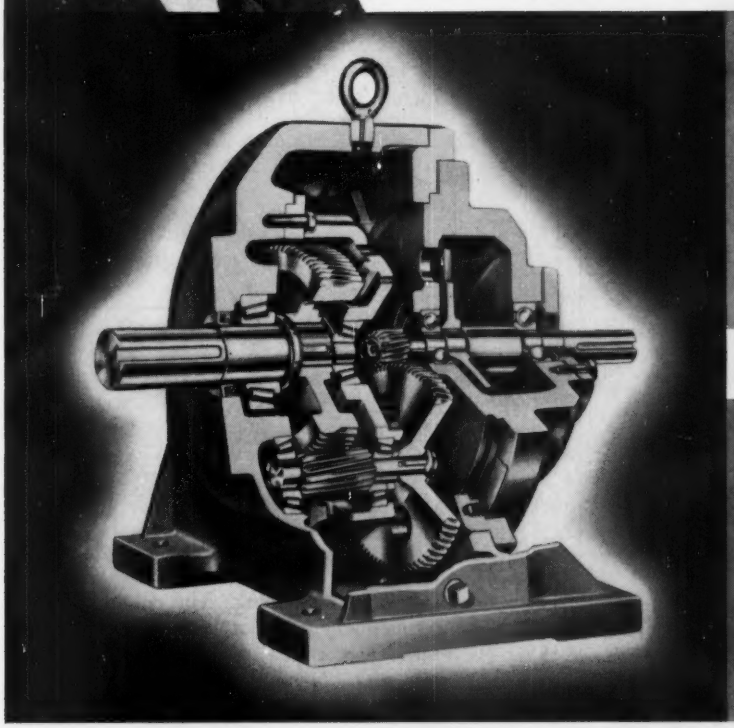
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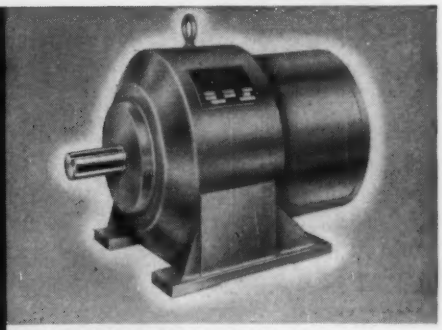
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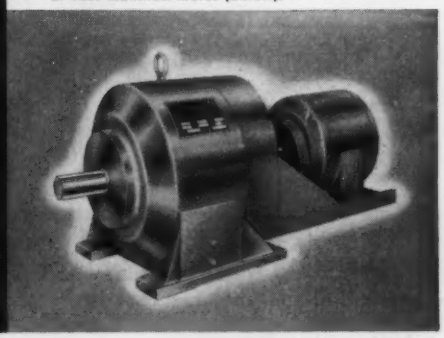
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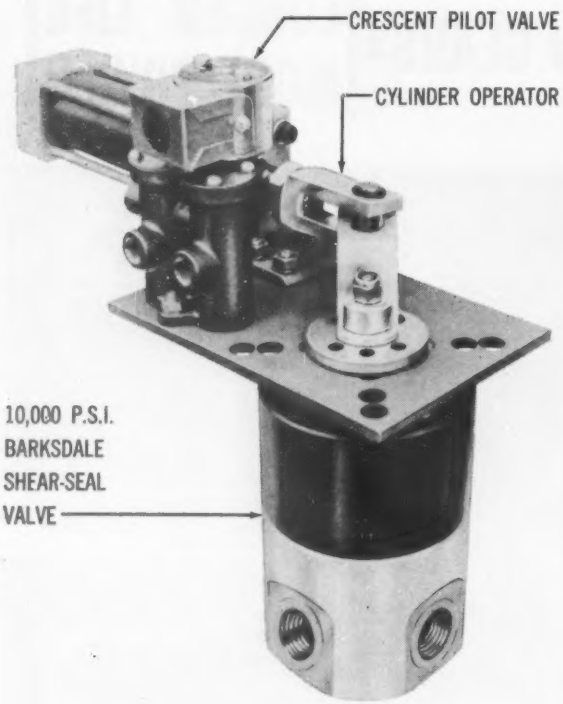
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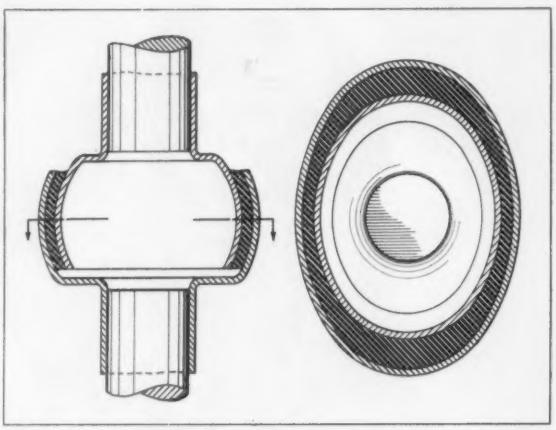
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NOTEWORTHY

# Patents

### *Elliptical Vibration Damper*

Torsional vibrations between shafts are damped by an elliptical-shaped elastic element, as rubber, in both first and second modes. At low amplitudes the stress in rubber is chiefly shear, which is effective in first mode damping. Compressive stresses prevail at high amplitudes to increase the spring rate. The higher spring rate increases the natural frequency and is ef-

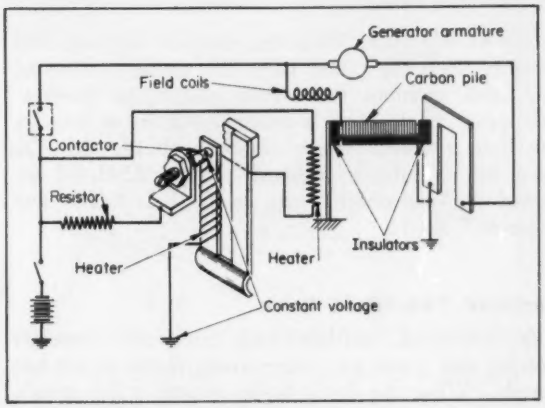


fective for second mode damping. The elliptical design also minimizes permanent set or bond failure because of excessive deformations. *Patent* 2,948,129 *assigned to Schwitzer Corp., Indianapolis, by William J. Troyer.*

**Skidproof antifriction bearing** of the roller type is attained by an out-of-round inner race. The magnitude of out-of-roundness is such that the major diameter plus two roller diameters give a calculated interference fit within the outside race of 0.001 to 0.002 in. per in. of diameter. The squeezed rollers positively drive the cage under light loads as well as under heavy loads and skidding is prevented at all angular positions. An alternative method is out-of-roundness of the outer race. *Patent* 2,943,894 *assigned to United Aircraft Corp., East Hartford, Conn., by Niles J. Brook.*

### *Constant Voltage-Output Device*

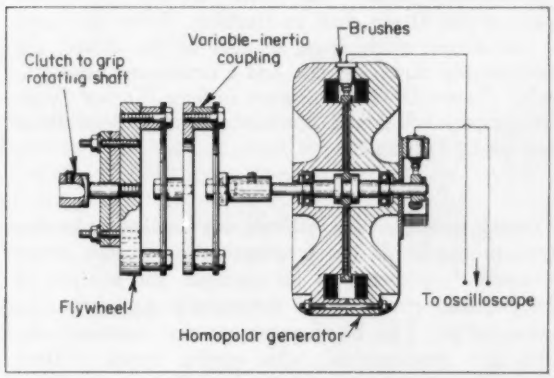
Bimetallic components transform the voltage of a widely variable source into a substantially constant voltage output. At low battery voltages and the associated low heating of the bimetallic units, the generator field voltage is high and the charging rate of the generator is high enough to maintain normal voltage. With normal battery voltage, the circuit is broken at the contactor so that no current flows through the re-




sistor. The bimetallic units act to increase the resistance of the carbon pile. The field current is low and the generator voltage remains near normal. *Patent* 2,944,209 *assigned to King-Seely Corp., Ann Arbor, Mich., by Charles W. Klug.*

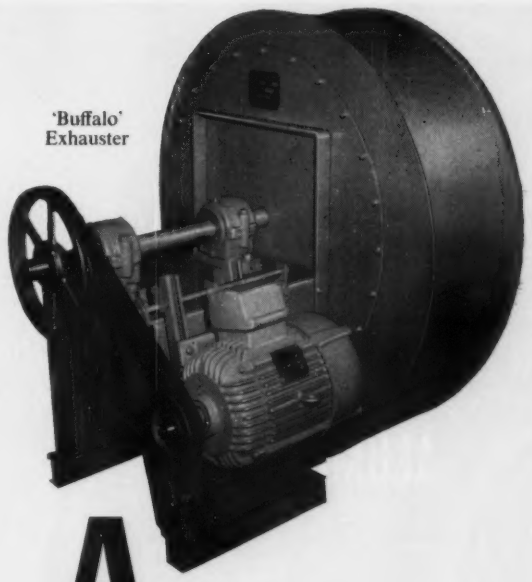
### *Rotary-Motion Analyzer*

Separate voltage outputs from a homopolar generator are used to measure the speeds and accelerations of rotating shafts. That voltage, for example, which corresponds to the first derivative of the speed is directly proportional to the acceleration and, therefore, to the torque output of the shaft. The differentiating circuit contains a capacitor and an inverting amplifier. As the input voltage to the amplifier increases in a positive direction, the output increases in a negative direction, and vice versa. A portion of the amplifier output voltage is fed back to the amplifier input by




a parallel-connected resistor and a secondary capacitor. Thus, the grid potential of the amplifier remains almost constant while the output voltage is directly proportional to the voltage across the capacitor but in an opposite direction. *Patent* 2,944,419 *assigned to A. O. Smith Corp., Milwaukee, by Alex Paalu.*

**Pump wobble plate** is returned to the zero position for stopping by a compression spring and the relief of the pressure in the wobble-plate positioning cylinder. The spring acts directly upon the actuating piston


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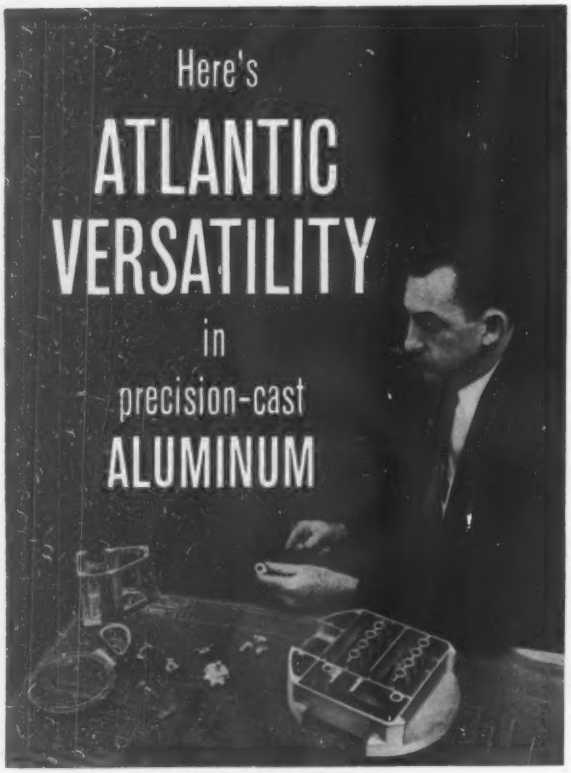
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Circle 619 on Page 19




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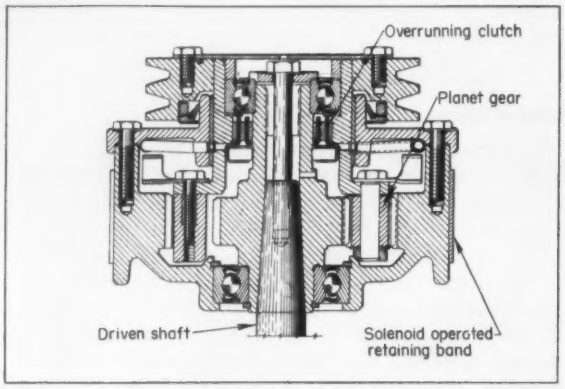
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to the wobble plate. While the pump is running, fluid pressure upon the piston keeps the spring compressed and, also, positions the wobble plate. The deceleration prior to stopping is accompanied by a drop in the fluid pressure, which causes a shuttle valve to open the cylinder to exhaust. *Patent* 2,941,480 *assigned to Sundstrand Corp., by Carl L. Sadler and Frederic T. Fariss.*

### *Enclosed Two-Speed Drive*

Self-contained, self-lubricated drive uses planetary gearing and a one-way overrunning clutch to get two speeds. When the driver pulley rotates at low speeds, the ring gear of the planetary train is kept from rotating by a retaining band; the planetary arrangement causes the driven shaft to rotate faster than the driver



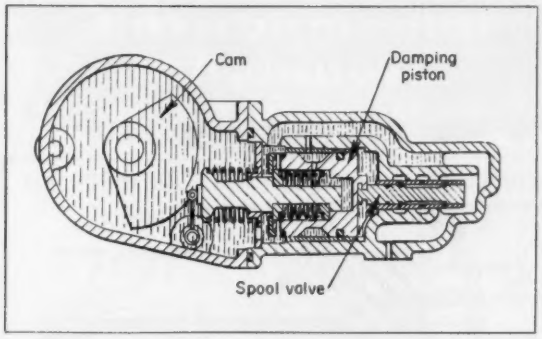

rotation. At a predetermined speed, a solenoid releases the retaining band. The freed ring-gear allows the speed of the driven shaft to diminish. When the speed of the driven shaft drops to that of the driver, the overrunning clutch engages and a one-to-one ratio prevails. *Patent* 2,943,517 *assigned to Borg-Warner Corp., Chicago, by William F. Markley, Henri A. Brysselbout and Richard L. Smirl.*

**Sweep generator for cathode ray oscillographs** has constant amplitude but is adaptable to a wide range of sweep frequencies, as for example, the analysis of the electrical circuit of an automobile engine over its speed range. The input pulses to the electrical systems are synchronized with engine speed. *Patent* 2,948,857 *assigned to Land-Air Inc., Chicago, by Warren W. Welcome.*

### *Air-Spring Control-Valve Assembly*

A cam-and-follower mechanism initiates the regulation of the pressure to an air spring for maintaining a constant vehicle elevation upon changes in loading. A counterclockwise movement of the cam, for example, occurs with a decrease in load. The displacement of the follower compresses a helical spring. The energy stored in the spring tends to move the piston, but full displacement of the piston is delayed because the oil

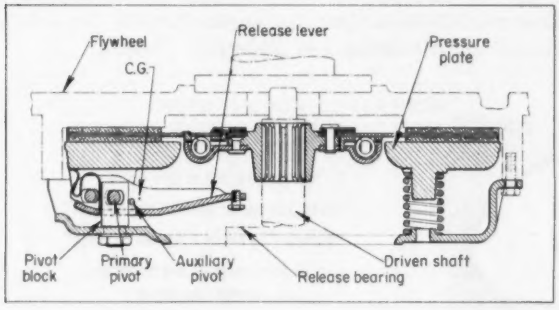

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moved by it is throttled. When the piston is fully displaced, the spool valve releases the fluid in the pressure line to the air spring. Self-adjustment of the air spring to suit the reduced pressure restores the cam to normal position by a clockwise rotation. *Patent* 2,945,690 *assigned to Westinghouse Air Brake Co., Wilmerding, Pa., by Harry C. May and Joseph F. Frola.*

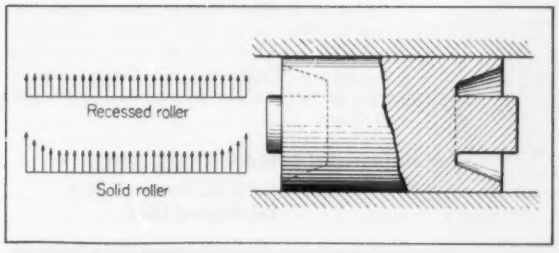
### Clutch Release Lever

Auxiliary pivots in conjunction with centrifugal force cause clutch release levers to be displaced away from the clutch release bearing instead of toward it. Slight radial displacements of the levers under centrifugal

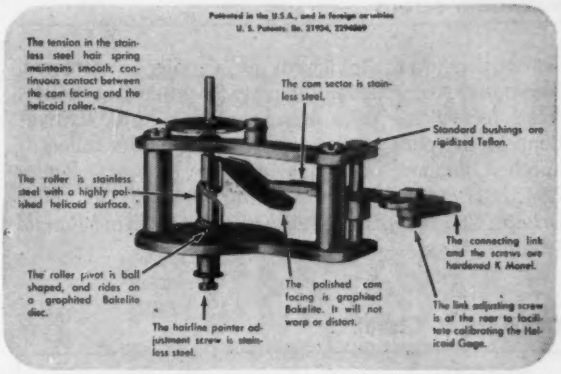



force seat the auxiliary pivots against flat pivot blocks. When the levers are released by the release bearing, the auxiliary pivots move away from the pivot blocks and the levers turn about the primary pivots in the customary manner. *Patent* 2,947,398 *assigned to Borg-Warner Corp., Chicago, by Joseph M. Willene.*

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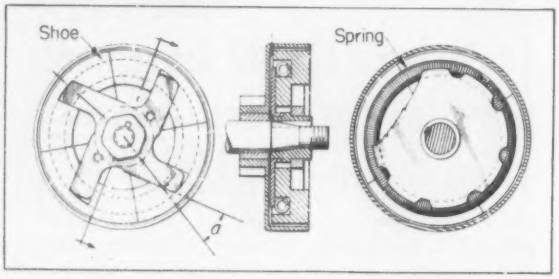
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Circle 621 on Page 19

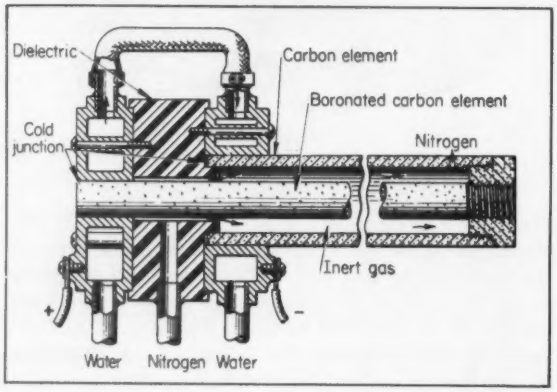
distribution over the length of a roller is attained. Alternative construction employs overhanging hollow roller force-fitted on a shorter pin or hub. Excavations in the ends of the races instead of the rollers is another method of equalizing the stresses. *Patent* 2,947,581 *assigned to the Fafnir Bearing Co., New Britain, Conn., by Horace Bishop Van Dorn and Ronald Wesson Moran.*

### Centrifugal Clutch



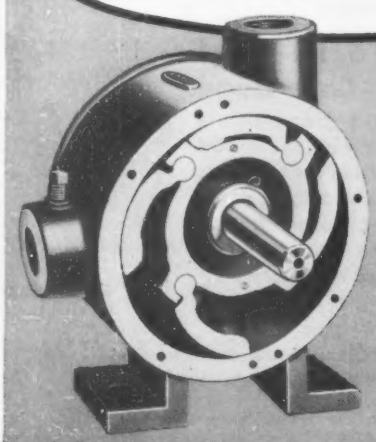

Engagement of a friction clutch is accomplished by sectorial shoes that begin movement outward against a drum in response to centrifugal force. Oblique cam surfaces on a spider amplify the pressure between the shoes and the drum with additional outward movement of the shoes. The cam action assures positive clutching so long as speed is maintained. When the clutch is operating at idling speed, a tension spring holds the shoes out of contact with the drum. *Patent* 2,947,399 *assigned to McCulloch Corp., Los Angeles, by Harold E. Moore and Harry I. Hazzard.*

### High-Temperature Thermocouple




Temperatures in excess of 2000 C (3632 F) are measurable with a thermocouple having one element of crystalline carbon rod thermoelectrically modified by boron as an impurity. The amount of boron is between 0.1 and 5 per cent by weight. The other element is carbon. The electrical output of the carbon-carbon boron thermocouple is over 100 millivolts at 3000 C. *Patent* 2,946,835 *assigned to Union Carbide Corp. by Russell D. Westbrook and Robert L. Shepard.*

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Established 1887

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Vacuum to 29.9" Hg. Pressure to 20 p.s.i.g. Volume to 162 c.f.m.

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**RANGES**

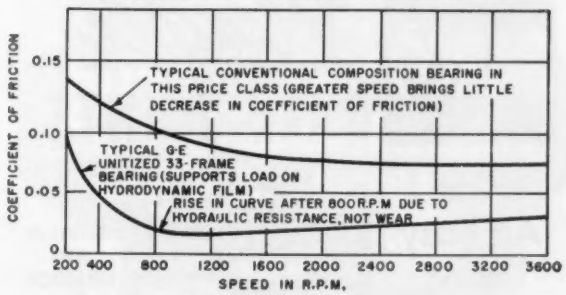
**Temperature:** —225° F. to +1000° F.
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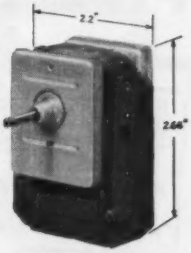
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**GENERAL ELECTRIC VS. CONVENTIONAL MOTOR**




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* Trademark of General Electric Co.




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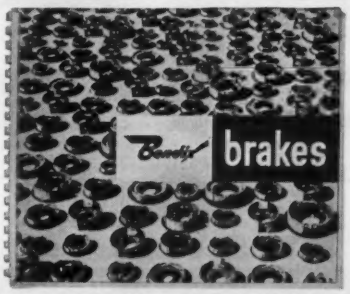
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**GENERAL ELECTRIC**

*Circle 624 on Page 19*

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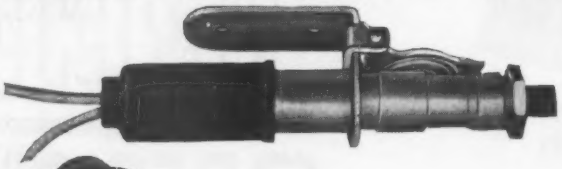
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THE Bendix CORPORATION

Bendix PRODUCTS DIVISION South Bend, IND.

*Circle 625 on Page 19*

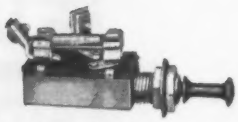
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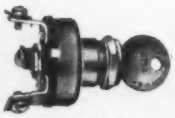
No. 9524 Combination Rotary Ignition & Light Switch



No. 5053 Push Pull Fused Light Switch



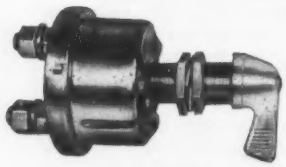
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No. 9522 Key Operated Ignition & Light Switch

Plastic-Coated Solenoid Completely Waterproofed Non-Breakable Intermittent Duty Solenoid





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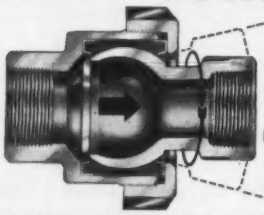
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Circle 627 on Page 19


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Circle 628 on Page 19

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actual size
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## MINIATURE 7/16" INDICATOR

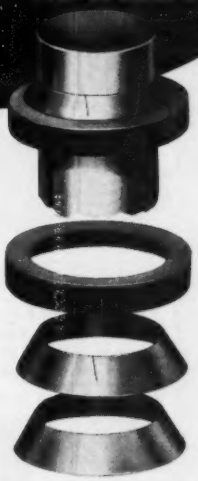
Micro-miniature moving coil, core magnet indicator; 7/16" diameter, 31/32" length. Weight 10 grams; sealed. Available with a pointer or flag display in a wide variety of electrical sensitivities and functions. Data on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, New Hampshire, U.S.A. *In Canada, Honeywell Controls Limited, Toronto 17, Ontario.*

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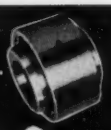
**Available in standard sizes for ¼ to 6 inch rod diameters. Larger sizes up to 24½" diameter by special order.**

*Detailed literature on request*

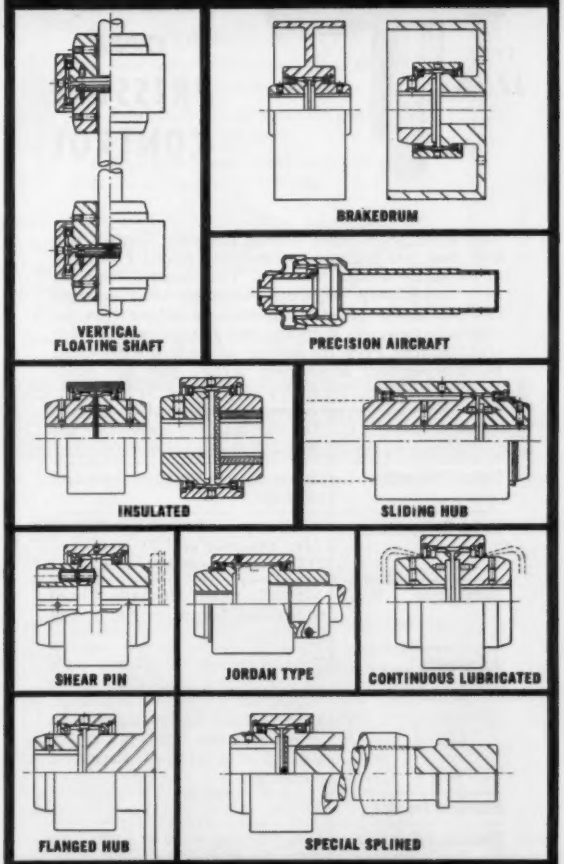
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Circle 630 on Page 19

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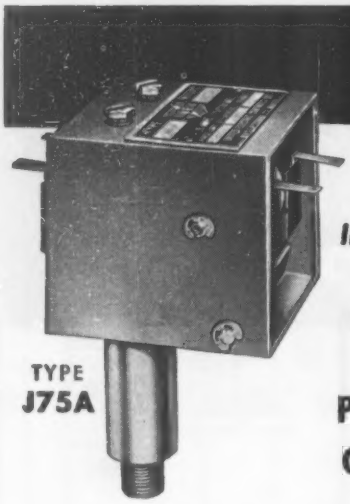


For complete information on the Sier-Bath Flexible Gear Coupling line, send for Catalog C-5 and Bulletin N-1.

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**Sier-Bath**
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Circle 631 on Page 19




# J75A

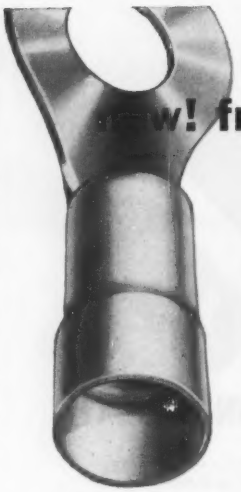
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| **Adjustable Ranges** . . . | Various ranges between 0 and 250 psi. |
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| **Switch Ratings** . . . . . | To 15 amps. at 115or230 volts A.C. Also available are 20 amps. A.C. D.C. switches also available. |
| **Switch Types** . . . . . | Normally Open, Normally Closed or Double Throw — no neutral position. |
| **Adjustments** . . . . . | Pressure settings individually made by independent adjustment screws located on top of switch bracket. Switches may be set together to simulate double pole circuitry or set apart to obtain independent operation. |
| **Maximum Pressure** . . . | 350 psi. |
| **Electrical Connections** . . | Lead wires attached to screw type terminals on switches. |
| **Pressure Connection** . . | Via a ⅛" male NPT connection. |
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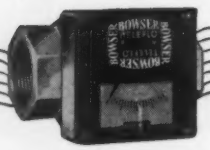

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990 East 67th Street, Cleveland 3, Ohio

Circle 633 on Page 19

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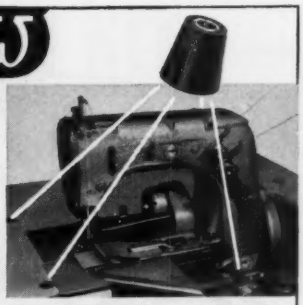



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Circle 634 on Page 19

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WILBOW Bonded Rubber Vibration Isolators contribute greatly to the smooth, quiet operation of Union Special Sewing Machines like this—for life!

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Circle 635 on Page 19


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***Compression & Tension Type***

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**Three Types:**

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3. *Extra Heavy Duty*—Compression Ult. Load 3050 lbs.; Ult. tension 3900 lbs.

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Circle 636 on Page 19





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**for heavy equipment designers**




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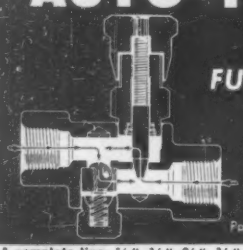
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Circle 638 on Page 19

# AUTO-PONENT®

## HYDRAULIC FULL FLOW VALVES



**Flow Control, Needle, Check, for HYDRAULIC Power**

Model KF Flow Control Valve with Dial and Knob adjustment for direct reading and duplicating reference. Now available in Aluminum for 3000 psi.

Pat. #2,841,174

**A complete line: ⅛", ¼", ⅜", ½", and ¾" female Dryseal Pipe Sizes in all models and types. Equivalent Aeronautical Tube Sizes on special order.**

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**FORGED BODIES** permit higher pressures with wide safety margins. Aluminum—3000 psi; Steel and Stainless Steel—5,000 psi. Pressure ratings based on better than 5 to 1 safety factor. All internal parts are Stainless. Write for illustrated catalog.



Model F Standard Flow Control Valve or Model N Needle Valve



Model KF Knob and Dial Flow Control Valve or Model KN Needle Valve.

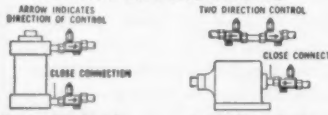


Model PF Knob and Dial Flow Control Valve or Model PN Needle Valve for panel mounting.



Model C Check Valve for In-Line Mounting.

### TYPICAL APPLICATIONS



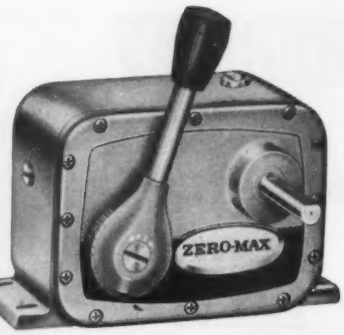

Controlling Double Acting Cylinder

Controlling Single Acting Cylinder

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ZERO-MAX

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Zero-Max "400 Series", a redesign of the complete line, gives you stepless variable speed control with a finger's touch. Over 250 fractional horsepower models and types (1/15 hp thru ¾ hp) with or without motors, reverse or gearhead – output range from zero to 1200 rpm with 1800 rpm input. Zero-Max gives smooth, stable drive and constant torque from 2½ to 450 inch-pounds.

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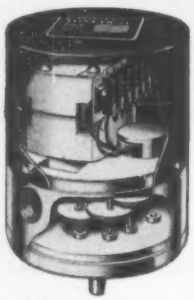
Circle 640 on Page 19

# AUTOMATIC and REMOTE POSITIONING CONTROLS

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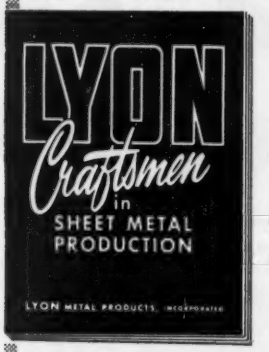
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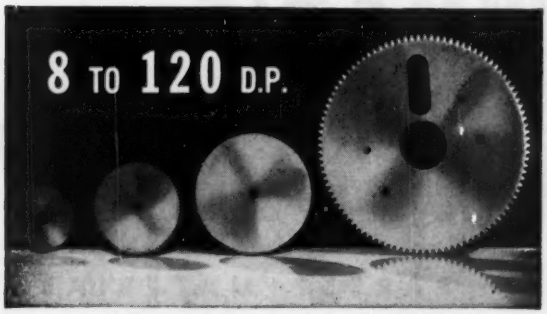



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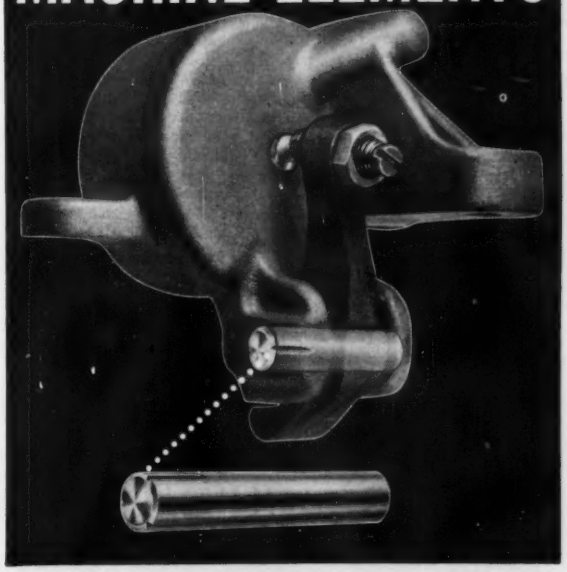
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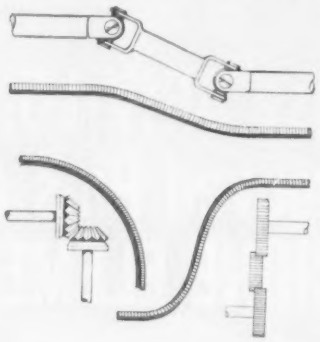
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## FLEXIBLE SHAFTING REDUCES GEARING

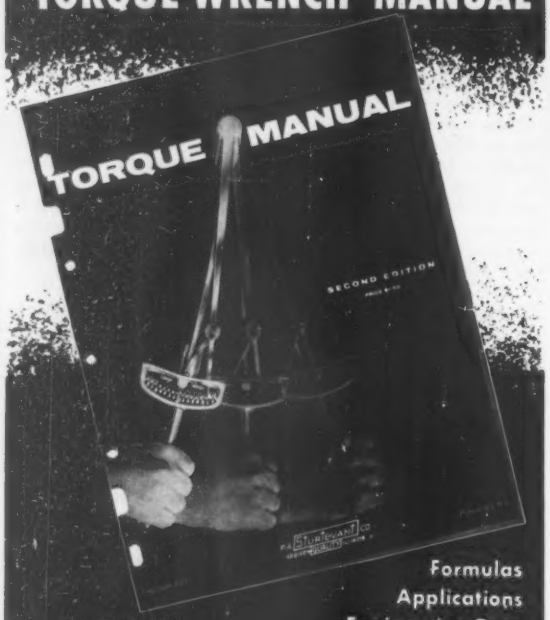


Flexible Shafting reduces the noisy and cumbrous gearing used in conjunction with solid shafts. It has the ability to transfer power from remote places, over, under, and around obstacles found in the path of installation between the drive and the driven units. Flexible Shafting requires very few parts, making them inexpensive; whereas solid shafts using universal joints, miter gears, and gear trains, many times would not be feasible because of their noisiness or lack of economy. With a Flexible Shaft assembly, design may be simplified and your engineering time spent on other necessary component parts without having to worry that they will create obstacles when pla.ed where you want them.

Flexible Shafting cuts down on vibration thus offering long life with very little maintenance required. For complete Flexible Shaft information, write F. W. Stewart Corporation, 4311 Ravenswood Ave., Chicago 13, Illinois.

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## "TORQUE WRENCH" MANUAL




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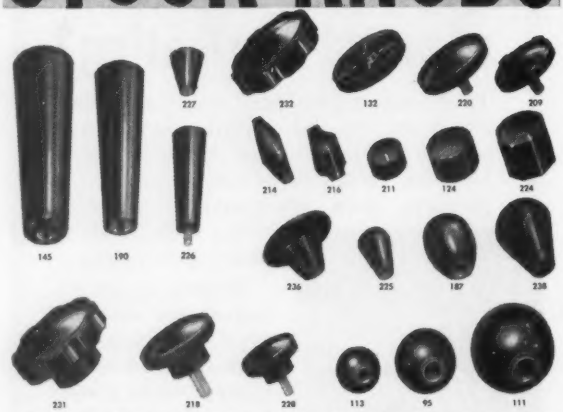
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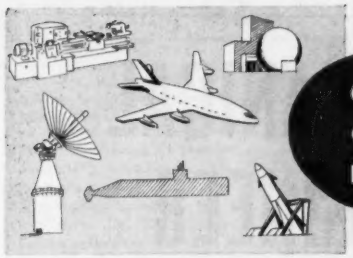
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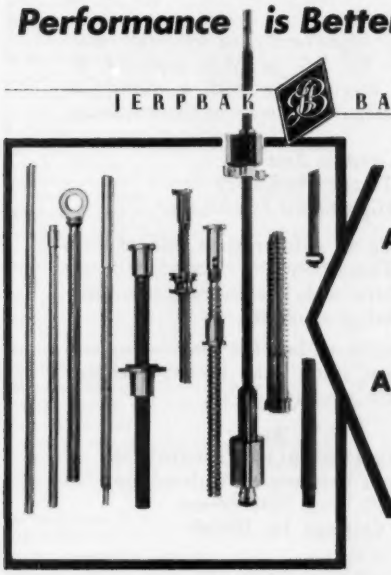


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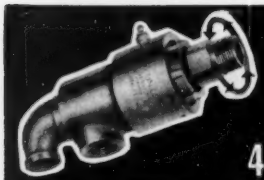
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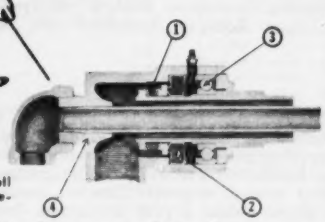
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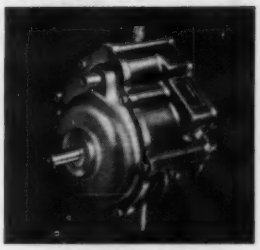
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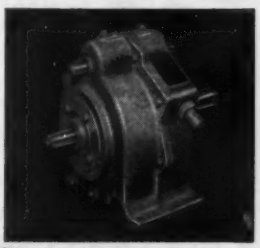
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*Now there are* **3** *Versatile*

# S-N REVERSING TRANSMISSIONS

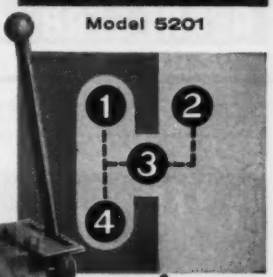


Model 5108

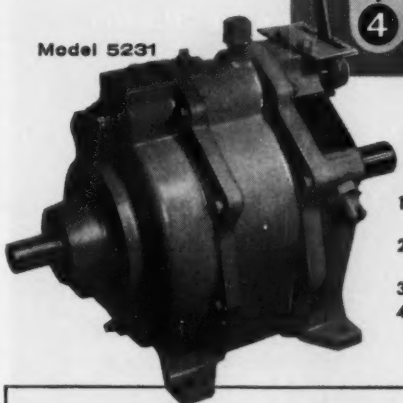


Model 5201

All designed to meet the demands for single, space saving units that reverse under full load. The newest, Model No. 5231, combines 2 speeds forward, neutral, reverse and reduction. Models 5201 and 5108 combine forward, neutral, reverse and reduction. All are performance proven. Technical literature is available. Specify model or description of potential application. Write the Industrial Division, The Snow-Nabstedt Gear Corp., Hamden, Connecticut.




Model 5231



1 FORWARD 3.34 Reduction
2 FORWARD 1.97 Reduction
3 NEUTRAL
4 REVERSE 3.37 Reduction

**SPECIFICATIONS**

| MODEL NO. | | 5231 | 5201 | 5108 |
|---|---|---|---|---|
| Reduction Ratio | Forward | 1.97:1 & 3.34:1 | 3.16:1 | 3.75:1 |
| | Reverse | 3.37:1 | 3.16:1 | 3.75:1 |
| Power Up To | | 28 HP | 28 HP | 8 HP |
| Maximum Input Torque | | 1000 in. lbs. | 1000 in. lbs. | 320 in. lbs. |
| Maximum Input Speed | | 2400 RPM | 2400 RPM | 2400 RPM |
| Dimensions | Long | 15 1/16" | 11 1/2" | 9 1/16" |
| | Wide | 14" | 12 1/2" | 10" |
| | High | 14 3/16" | 14 3/16" | 10 3/16" |

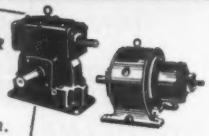
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FOR OVER HALF A CENTURY

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*Tell us about your particular requirements.*

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*Circle 653 on Page 19*

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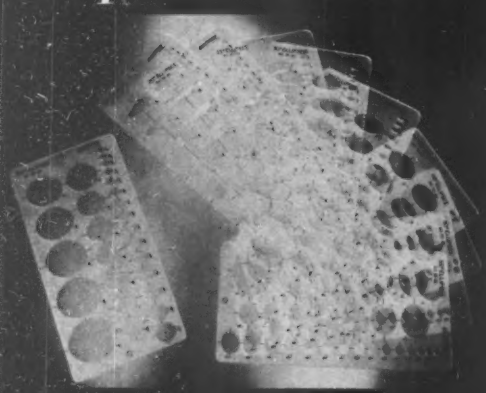
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Main 1-8260

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BPA NBP

# backtalk——

## ——The Professor on Professionalism

Charles E. Balleisen, associate professor of mechanical engineering, Southern Methodist University, shares some of his worthwhile thinking with us as a guest on the editorial page of this issue. Professor Balleisen, obviously a practicer of what he preaches, is a good, solid example of the professional engineer if we ever saw one.

He is twice registered (mechanical and industrial engineering), is a Fellow in the AAAS, an active member of ASME and ISA, a Fellow of the Texas Academy of Science, a member of the Franklin Institute of the State of Pennsylvania, and belongs to four honorary engineering fraternities. He has written articles for MACHINE DESIGN and other worthy publica-



tions, authored a book, has been granted nine patents, and has a master's degree plus to his educational credit.

Professor Balleisen also taught at Purdue; his nonacademic positions have been in supervision of testing, research, and development for Robertshaw-Fulton Controls Co., Southwest Research Institute, and the U. S. Army Ordnance Dept.

An egghead, possibly, but primarily a good egg, he signs his letters—even to comparative strangers—with a friendly "Charlie."

## ——Were You at the Design Show?

If you were, you may be able to offer assistance to the widow of an industrial engineer who found, at the show, a device which provided a long-sought solution to an application problem. The engineer, Lawrence Hagerman, called his wife from New York to tell her the good news that he had solved the problem and that their financial future was thus assured. Two days later he was killed in an accident on his way home.

Mr. Hagerman was looking for a drive—probably of the torque-limiting type—for an automatic decorating machine used to print labels on glass containers. He attended two sessions of the Design Engineering Conference: The one on power and control on May 24, and the session on automation on May 25. No information is available regarding exhibitors or other show visitors to whom Mr. Hagerman talked.

Mrs. Hagerman would appreciate hearing from anyone who may be able to shed any light on her husband's discovery, since it would "make a real difference" in her plans for their five children. If you know anything about this matter, please write to Mrs. Dorothy Hagerman, 12019 S. Shoemaker, Santa Fe Springs, Calif.

## ——We Make Book(s)

Clear a space on your book shelf, because you will soon start collecting a fine set of reference manuals. How do we know this? We're going to send them to you, that's how.

Accompanying the next issue of MACHINE DESIGN will be a second publication called *The Fasteners Book*, the first of a family of handbooks devoted to components and materials information which a design engineer needs at hand. Each handbook will contain a Design Data section and a Directory. The data part will bring you chapters by various experts—people in industry, universities, and associations; consultants; and MACHINE DESIGN editors. After you've read how to select and apply, you can turn to the directory pages for where-to-find-it information.

Following *The Fasteners Book*, manuals on seals, bearings, ferrous metals, and electric motors will be published next year. After that, additional subjects will be covered and, because (1) we mean to keep our manuals up-to-date and (2) you'll probably wear your copies out, all of them will be revised periodically.

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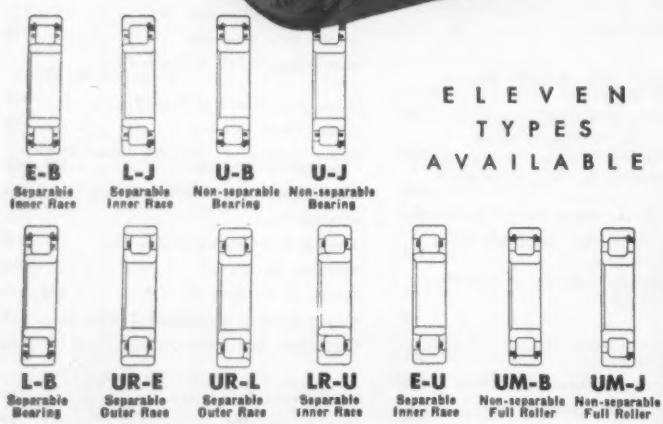
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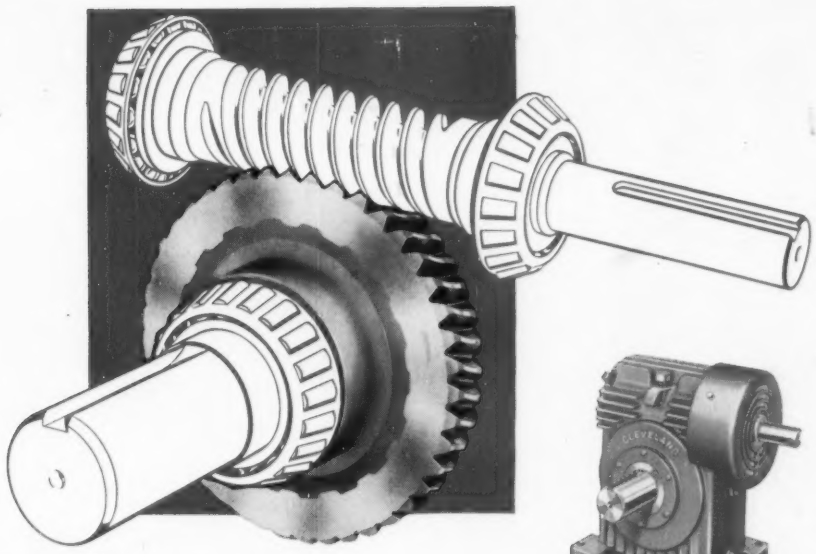
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Providing higher input horsepower and output torque ratings, *New* Cleveland Speed Reducers now give industry dependable speed reduction at savings of 50% or more on per horsepower cost—without increasing size of the units.

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These rugged bronze rims are cast integrally with their supporting cast iron hubs (see photo at right). Checkered hub circumference holds the rim securely in position, making the two members independent of actual surface bond.

Also, another plus value of the New Cleveland Reducers is their especially large gear shaft diameters—which provide greatly increased overhung load carrying capacity.

For complete facts on this New Cleveland Speed Reducer Line, consult your local Cleveland Representative. Or, write us direct for free Bulletin No. 405—it gives *complete* engineering information for designers and engineers.



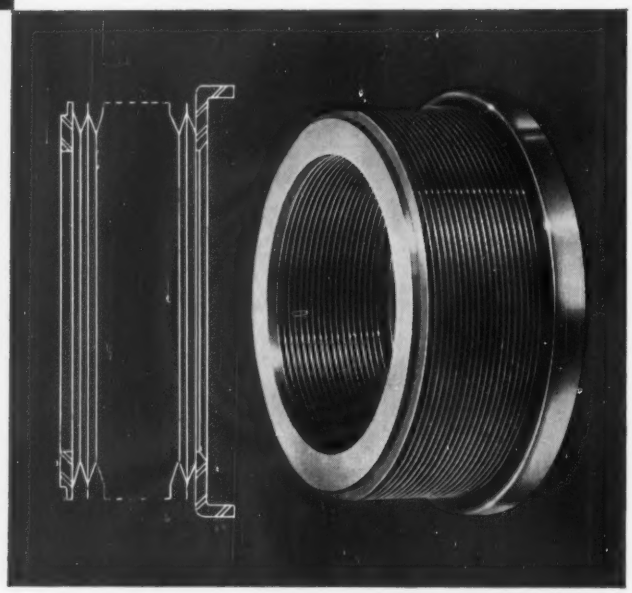
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C/R DESIGN NOTES

# How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



## Operating Ranges

| | |
|---|---|
| Temperature | −400° to 1000° F. |
| Pressure | 500 psi |
| R.P.M. | 80,000 plus |

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

## Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

## Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

## Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

## Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

***Helpful Design Data:***

*We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.*

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